Cisco 3900 Series, Cisco 2900 Series, and Cisco 1900 Series Integrated Services Routers Generation 2 Software Configuration Guide

April 10, 2015

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www.cisco.com

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Preface

This preface describes the objectives, audience, organization, conventions of this guide, and the references that accompany this document set. The following sections are provided:

- Objectives, page 1
- Audience, page 1
- Organization, page 1
- Conventions, page 3
- Related Documentation, page 4
- Searching Cisco Documents, page 5

Objectives

This guide provides an overview and explains how to configure the various features for the Cisco 1900 series, Cisco 2900 series, and Cisco 3900 series integrated services routers generation 2 (ISR G2). Some information may not apply to your particular router model.

Audience

This document is written for experienced technical workers who install, monitor, and troubleshoot routers under a service contract, or who work for an information technology (IT) department.

Organization

This guide is divided into three parts:

- Part 1—Configuring the Router
- Part 2—Configuring the Access Point
- Part 3—Appendix

Part 1	Configuring the Router	Description
Module 1	Overview of Hardware and Software	Describes new hardware and software features in this release, features by platform, new slots, common ports, and getting started tasks.
Module 2	Basic Router Configuration	Describes how to perform the basic router configuration, interface configuration, and routing configuration.
Module 3	Configuring Backup Data Lines and Remote Management	Describes how to configure backup interfaces, dial backup, and remote management.
Module 4	Configuring Power Efficiency Management	Describes the hardware and software power efficiency management features on the router. See *Cisco EnergyWise Configuration Guide* for information about configuring power efficiency management on modules and interface.
Module 5	Configuring Security Features	Describes how to configure security features.
Module 6	Unified Communications on Cisco Integrated Services Routers	Describes voice application services that are supported on these routers.
Module 7	Configuring Next-Generation High-Density PVDM3 Modules	Describes how to configure the new next-generation PVDM3[1] installed on your router.
Module 8	Multi-Gigabit Fabric Communication	Describes how modules and interface cards inter-communicate using the MGF[2] on the router.
Module 9	Upgrading the Cisco IOS Software	Describes how to upgrade the Cisco IOS software image on the router or the access point.
Part 2	**Configuring the Access Point**	**Description**
Module 1	Wireless Overview	Describes the autonomous image and recovery image shipped on the Cisco 1941W access point flash. Explains the default autonomous mode and Cisco Unified mode.
Module 2	Configuring the Wireless Device	Describes how to configure the autonomous wireless device, how to upgrade the autonomous software to Cisco Unified software, and how to configure a Unified wireless device.
Module 3	Configuring the Radio Settings	Describes how to configure the radio settings for the wireless device.
Module 4	Administering the Wireless Device	Describes many administration tasks for the wireless device.
Part 3	**Appendix**	**Description**
Appendix A	Cisco IOS CLI for Initial Configuration	Describes how to perform the initial configuration of the router using the Cisco IOS CLI, and additional configuration procedures for the router.

Appendix B	Using CompactFlash Memory Cards	Describes how to use Advanced Capability CF[3] memory cards on the router.
Appendix C	Using ROM Monitor	Describes how to use the ROM monitor to manually load a system image, upgrade the system image when there are no TFTP servers or network connections, or prepare for disaster recovery.
Appendix D	Changing the Configuration Register Settings	Describes the 16-bit configuration register in NVRAM and how to make changes to the register settings using the Cisco IOS CLI.

1. PVDM3 = packet voice/data module
2. MGF = Multi-Gigabit Fabric.
3. CF = CompactFlash.

Conventions

This document uses the following conventions:

Convention	Indication
bold font	Commands and keywords and user-entered text appear in **bold** font.
italic font	Document titles, new or emphasized terms, and arguments for which you supply values are in *italic* font.
[ ]	Elements in square brackets are optional.
{x | y | z }	Required alternative keywords are grouped in braces and separated by vertical bars.
[x | y | z]	Optional alternative keywords are grouped in brackets and separated by vertical bars.
string	A nonquoted set of characters. Do not use quotation marks around the string or the string will include the quotation marks.
`courier` font	Terminal sessions and information the system displays appear in `courier` font.
< >	Non-printing characters such as passwords are in angle brackets.
[ ]	Default responses to system prompts are in square brackets.
!, #	An exclamation point (!) or a pound sign (#) at the beginning of a line of code indicates a comment line.

Note Means *reader take note*.

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

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

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

Warning **Means *reader be warned*. In this situation, you might perform an action that could result in bodily injury.**

Related Documentation

In addition to the Cisco 1900 series, Cisco 2900 series, and Cisco 3900 series ISR Software Configuration Guide (this document), the following reference guides are included:

Type of Document	Links
Hardware	• Read Me First for the Cisco 1900 Series, 2900 Series, and 3900 Series Integrated Services Routers. • *Regulatory Compliance and Safety Information for Cisco 1900 Series Integrated Services Routers.* • *Cisco 2900 Series and 3900 Series Integrated Services Routers Hardware Installation Guide* • *Cisco 1900 Series Integrated Services Routers Hardware Installation Guide.* • *Cisco Modular Access Router Cable Specifications* • *Installing, Replacing, and Upgrading Components in Cisco Modular Access Routers and Integrated Services Routers* • *Overview of Cisco Network Modules for Cisco Access Routers* • *Cisco Interface Cards for Cisco Access Routers* • *Installing Cisco Network Modules in Cisco Access Routers* • *Installing Cisco Interface Cards in Cisco Access Routers*
Regulatory Compliance	• *Declarations of Conformity and Regulatory Information for Cisco Access Products with 802.11a/b/g and 802.11b/g Radios* • *Regulatory Compliance and Safety Information for Cisco 2900 Series Integrated Services Routers* • *Regulatory Compliance and Safety Information for Cisco 3900 Series Integrated Services Routers*
Software Activation	• *Software Activation for Cisco Integrated Services Routers* • *Cisco IOS Software Activation Configuration Guide*
Configuration	• *Cisco CP Express User's Guide*

Type of Document	Links
Cisco Internet Operating System Software (IOS)	Cisco IOS software release 15.0 is the next IOS release following the Cisco IOS 12.4(24)T release. For information about new features in Cisco IOS software release 15.0, see the Cisco IOS software pages at Cisco.com. Go here to read a product bulletin that specifies the software feature sets available for Cisco 1900, 2900 and 3900 Series Integrated Services Routers in release 15.0. It also issues recommendations for Flash and DRAM memory configuration. *http://www.cisco.com/en/US/prod/collateral/iosswrel/ps8802/ps5460/product_bulletin_c25-566278_ps10537_Products_Bulletin.html*
Wireless	• *Cisco IOS Command Reference for Cisco Aironet Access Points and Bridges, versions 12.4(10b) JA and 12.3(8) JEC* • *Wireless LAN Controllers* • *Unified Wireless LAN Access Points*
Voice	• *Cisco IOS Voice Port Configuration Guide* • *SCCP Controlled Analog (FXS) Ports with Supplementary Features in Cisco IOS Gateways*
Modules	• *Cisco SRE Internal Service Modules Configuration Guide.* • *Cisco Services Ready Engine Configuration Guide.* • *Cisco SRE Service Modules Configuration Guide.* • *Connecting Cisco EtherSwitch Service Modules to the Network.* • *Cisco EtherSwitch Service Modules Feature Guide.*

Searching Cisco Documents

To search a Hyper Text Markup Language (HTML) document using a web browser, press **Ctrl-F** (Windows) or **Cmd-F** (Apple). In most browsers, the option to search whole words only, invoke case sensitivity, or search forward and backward is also available.

To search a PDF document in Adobe Reader, use the basic Find toolbar **(Ctrl-F)** or the Full Reader Search window **(Shift-Ctrl-F)**. Use the Find toolbar to find words or phrases within a specific document. Use the Full Reader Search window to search multiple PDF files simultaneously and to change case sensitivity and other options. Adobe Reader's online help has more information about how to search PDF documents.

Overview of the Hardware and Software

The Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series integrated services routers (ISRs) offer secure, wire-speed delivery of concurrent data, voice, and video services. The modular design of these routers provides maximum flexibility, allowing you to configure your router to meet evolving needs.

The routers offer features such as hardware-based virtual private network (VPN) encryption acceleration, intrusion-protection and firewall functions, and optional integrated call processing and voice mail. A wide variety of legacy network modules and interfaces, service modules (SMs), internal services modules (ISMs), next-generation packet voice/data modules (PVDM3), Services Performance Engines (SPEs), high-density interfaces for a wide range of connectivity requirements, and sufficient performance and slot density for future network expansion requirements and advanced applications are available.

Power-saving hardware and software features are incorporated throughout the series. These routers provide access to the multi-gigabit fabric, which provides a connection between switch ports without using up external ports. The logical Gigabit Ethernet (GE) interface on the router connects external and internal modules through the backplane for LAN and WAN switching. Software feature upgrades are provided through software licensing.

The following sections describe the Cisco 3900 series, 2900 series, and 1900 series ISRs:

- Feature Information, page 2
- New Features by Platform, page 4
- New Slots, page 4
- New Slots and Ports by Platform, page 5
- Common Ports, page 6
- Licensing, page 6
- Getting Started, page 7

Feature Information

Table 1 Feature Information

Feature	Description
Services Performance Engine	SPEs[1] are modular motherboards on Cisco 3900 series ISRs. The SPE houses PVDM3 slots, system memory slots, and the ISM slot. The SPE provides a modular approach to system upgrades. You simply slide out the SPE from the router to replace internal modules, or upgrade the SPE to improve router performance. See *Cisco 2900 series and 3900 series Integrated Services Routers Hardware Installation Guide* for instructions.
Cryptographic Engine Accelerator	Cisco 3900 series routers with either Services Performance Engine 200 or Services Performance Engine 250 have an onboard cryptographic accelerator that is shared between SSLVPN and IPSec. By default, acceleration of SSL is disabled so IPSec performance is maximized. See the "Configuring Security Features" section on page 123 in this guide for information about enabling the SSLVPN feature.
USB Console	Cisco 3900 series, 2900 series, and 1900 series ISRs provide an additional mechanism for configuring the system through a USB[2] serial console port. The traditional RJ-45 serial console port is also available.
Power Management	Some modules and interface cards that are inserted in new slots provide hardware and software power management features described below: • High efficiency AC power supplies • Electrical components with built-in power saving features, such as RAM select and clock gating • Ability to disable unused clocks to modules and peripherals • Ability to power down unused modules and put peripherals into a reset state, put front panel ports and unused internal components in a shutdown or reset state
Advanced Capability CompactFlash	Cisco 3900 series, 2900 series, and 1900 series ISRs use Advanced Capability CF[3] memory to store the system image, configuration files, and some software data files.
SFP/Gigabit Ethernet Port	Cisco 2921, Cisco 2951 and Cisco 3900 Series routers have an SFP/Gigabit Ethernet port that supports copper and fiber concurrent connections. Media can be configured for failover redundancy when the network goes down. For more information, see the "Configuring Backup Data Lines and Remote Management" section on page 93.

Table 1 Feature Information (continued)

Feature	Description
New Modules and Interface Cards	Cisco 3900 series, 2900 series, and 1900 series ISRs introduce the following new modules and interface cards, which are inserted in the following new router slots: • EHWIC • PVDM3 • ISM • SM **Note** See the router's product page at Cisco.com for a complete list of supported modules and interfaces.
Multi-Gigabit Fabric Communication	Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series ISRs use a MGF[4] for the new modules and interface cards to inter-communicate on the router. Legacy modules that support Cisco HIMI[5] also support MGF to inter-communicate on the router. Next generation module drivers integrate with the MGF to perform port configurations, configure packet flow, and control traffic buffering. All configurations are performed from the module-side, which may or may not lead to changes on the MGF. For more information, see the "Configuring Multi-Gigabit Fabric Communication" section on page 207.
Integrated Application Services Features	Cisco 3900 series, 2900 series, and 1900 series ISRs offer integrated security features and voice features. • See the "Configuring Security Features" section on page 123 • See the "Unified Communications on Cisco Integrated Services Routers" section on page 165

1. SPE = Services Performance Engine
2. USB = universal serial bus
3. CF = CompactFlash
4. MGF = multi-gigabit fabric
5. HIMI = High-Speed Intrachassis Module Interconnect

New Features by Platform

Table 2 shows new feature support by platform.

Table 2 New Features in this Release by Platform

Features	1941	1941W	2901	2911	2921	2951	3925	3925E	3945	3945E
Services Performance Engine	N	N	N	N	N	N	Y	Y	Y	Y
Cryptographic Engine Acceleration	N	N	N	N	N	N	Y[1]	Y	Y[2]	Y
USB Serial Console	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Power Management	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
New Module and Interface Card Features	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Advanced Capability CompactFlash	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SFP/Gigabit Ethernet Port	N	N	N	N	Y	Y	Y	Y	Y	Y
Multi-Gigabit Fabric Communication	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Integrated Application Services	Y[3]	Y[4]	Y	Y	Y	Y	Y	Y	Y	Y

1. Must have Services Performance Engine 200 installed in the router.
2. Must have Services Performance Engine 250 installed in the router.
3. Does not support Voice application services.
4. Does not support Voice application services. Includes embedded wireless access point that supports Cisco Unified Wireless Architecture.

New Slots

Cisco 3900 series, 2900 series, and 1900 series ISRs have introduced new slots on the chassis. The first column in Table 3 lists the new slot names. The second column lists the corresponding old slot names. Modules previously inserted in the old slots now insert in the new slots with the help of an adapter card.

For instance, network modules (NMs), enhanced network modules (NMEs), and extension voice modules (EVMs) use an adapter, or carrier card, to insert into the SM slot. See your router's hardware installation guide for adapter information.

Table 3 New Slot Names and Old Slot Names

New Slot Names	Old Slot Names
EHWIC	HWIC,HWIC-DW, WIC, VWIC, VIC
ISM	AIM[1]
PVDM3	PVDM
SM	NM, NME, EVM
SPE[2]	—

1. AIM is not supported in this release. See your hardware installation guide for more information.
2. The SPE is available only on the Cisco 3900 series ISRs.

New Slots and Ports by Platform

This section provides the type and number of the slots and ports available in the Cisco 3900 series, 2900 series, and 1900 series ISRs.

- Cisco 3900 Series ISRs, page 5
- Cisco 2900 Series ISRs, page 5
- Cisco 1900 Series ISRs, page 6

Cisco 3900 Series ISRs

Table 4 lists the slots and ports available on Cisco 3900 series routers.

To view the installation guide, see the following URL
http://www.cisco.com/en/US/docs/routers/access/2900/hardware/installation/guide/Hardware_Installation_Guide.html

Table 4 Cisco 3900 Series Routers

Router	EHWIC	SM	Dbl-Wide SM	ISM	PVDM3	CF	GE (RJ-45)/ SFP ports	SPE
Cisco 3945	4	4	1	1	4	2	3[1]	1
Cisco 3945E	3	4	1	0	3	2	4[2]	1
Cisco 3925	4	2	1	1	4	2	3[3]	1
Cisco 3925E	3	2	1	0	3	2	4[4]	1

1. One RJ-45 GE + two combo GE/SFPs.
2. Four RJ-45 GE, or three RJ-45 GE + one combo GE/SFP, or two RJ-45 GE + two combo GE/SFP.
3. One RJ-45 GE + two combo GE/SFPs, or three RJ-45 GEs.
4. Four RJ-45 GE, or three RJ-45 GE + one combo GE/SFP, or two RJ-45 GE + two combo GE/SFP.

Cisco 2900 Series ISRs

Table 5 lists the slots and ports available on Cisco 2900 series routers.

To view the installation guide, see the following URL
http://www.cisco.com/en/US/docs/routers/access/2900/hardware/installation/guide/Hardware_Installation_Guide.html

Table 5 Cisco 2900 Series Routers

Router	EHWIC	SM	Dbl-Wide SM	ISM	PVDM3	CF	GE (RJ-45) ports	GE (RJ-45)/ SFP ports
Cisco 2951	4	2	2	1	3	2	2	1
Cisco 2921	4	1	1	1	3	2	2	1
Cisco 2911	4	1	1	1	2	2	3	0
Cisco 2901	4	0	0	1	2	2	3	0

Cisco 1900 Series ISRs

Table 6 lists the slots and ports available on Cisco 1900 series routers.

To view the installation guide, see the following URL
http://www.cisco.com/en/US/docs/routers/access/1900/hardware/installation/guide/1900_HIG.html

Table 6 Cisco 1900 Series ISR Routers

Router	EHWIC[1]	Dbl-Wide EHWIC	SM	Dbl-Wide SM	ISM	PVDM3	WLAN	CF	GE (RJ-45) ports
Cisco 1941	2	1	0	0	1	0	0	2	2
Cisco 1941W	2	1	0	0	0	0	1	2	2

1. One of the two EWHIC slots is adouble-wide EWHIC slot,giving the appearance of three EWHIC slots.

Common Ports

The following ports are common among Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series routers:

- Gigabit Ethernet RJ45—Ports available through an RJ45 connector.
- Gigabit Ethernet RJ45/SFP—Ports available through RJ45- SFP connectors. Connection supports fail-over if the secondary connection goes down.
- RS232 Aux—Supports modem control lines and remote administration for box-to-box redundancy applications.
- RS232 Serial Console—Supports modem control lines and remote administration of the router with the proprietary cable shipped in the box.
- Type A USB 2.0—Supports USB-based flash memory sticks, security tokens, and USB-compliant devices.
- Type B mini-port USB Serial Console—Supports modem control lines and remote administration of the router using a type B USB-compliant cable.

Licensing

Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series ISRs support Cisco IOS software entitlement. Your router is shipped with the software image and the corresponding permanent licenses for the technology packages and features that you specified preinstalled. You do not need to activate or register the software prior to use. If you need to upgrade or install a new technology package or feature see *Software Activation on Integrated Services Router*,

http://www.cisco.com/en/US/docs/routers/access/sw_activation/SA_on_ISR.html.

Getting Started

See the router-specific hardware installation guide to install the router in an appropriate location. Connect the router with the appropriate cables. Supply power to the router and perform the initial software configuration using Cisco Configuration Professional Express. After the initial configuration is completed, perform the following steps:

Step 1 Follow instructions in the "Basic Router Configuration" section on page 13 to perform additional router configurations.

Step 2 (Optional) If you are setting up the Cisco 1941W ISR, follow instructions in the "Configuring the Wireless Device" section on page 243 to configure the embedded wireless device on the router.

Step 3 Follow instructions in the "Configuring Security Features" section on page 123 to configure security features on the router.

Step 4 Follow instructions in the "Unified Communications on Cisco Integrated Services Routers" section on page 165 to configure Voice features on the router.

IOS Commands

Table 7 lists the Cisco IOS commands and features that can trigger an erase, write, or erase and write operation on a device's boot flash. The erase or write of an attribute on the boot flash can hold the CPU for a few milliseconds to complete the operation. The CPU hold can result in a functional impact on protocols or applications that are extremely time sensitive, for instance, Bidirectional Forwarding Detection (BFD) or routing protocols which use finely tuned short timers. For example, OSPF with fast hellos and short dead timers.

Table 7 Cisco IOS Commands

Functionality	Command Name	Description	Configuration Example	Impact

Write to NV memory.	**write memory**	This command writes the device's configuration in to the Non-Volatile RAM (NVRAM) on the boot flash. Use this command in privileged EXEC mode.	Router#**write memory**	A BFD flap is triggered when one of the following configuration elements are activated or deactivated and configuration is saved to memory:
				`(config)#warm-reboot`
				`(config)#boot config`
				`(config)#boot system`

Changing the configuration register value.	**config-register** *value*	The router has a 16-bit configuration register in NVRAM. Each bit has value 1 (on or set) or value 0 (off or clear), and each bit setting affects the router behavior upon the next reload power cycle. Use this command in Global configuration mode.	Router(config)# **config-register 0xvalue**	Potential enough to flap bfd.

Table 7 Cisco IOS Commands

Functionality	Command Name	Description	Configuration Example	Impact

Copy running configuration to startup configuration.	**copy running-config startup-config**	This command copies running configuration to startup configuration.	Router#**copy running-config startup-config**	A BFD flap is not triggered for all 'write mem' commands. For instance, when the configuration attributes changes without either a write or an erase+write on the NVRAM, the BFD is not triggered.
				In the following example, when one of the configuration elements are activated/deactivated and the configuration is saved using the 'write mem' command, the flap is triggered:
				`(config)#warm-reboot`
				`(config)#boot config`
				`(config)#boot system`

Changing boot variables.	**boot** {**bootstrap** | **config** |**host**| **netowrk** | **system**}	This command configures bootstrap image file, configuration file, router specific config file, Networkwide config file or system image file.	Router(config)#**boot bootstrap**	Potential enough to flap bfd.
Setting the system software clock manually.	**clock set hh:mm:ss day month year**	To manually set the system software clock, use one of the formats of the **clock set** command in privileged EXEC mode. **clock set hh:mm:ss day month year** **clock set hh:mm:ss month day year**	Router#**clock set 13:32:00 23 July 1997**	Potential enough to flap bfd. **Note** Every time the command is issued.

Table 7 Cisco IOS Commands

Functionality	Command Name	Description	Configuration Example	Impact
Random Entropy	No special Command exists for this.	After the system boot up, entropy is collected by accessing the security chip. This is potential enough to flap the BFD session immediately after the router boots up.	No command	Potential enough to flap bfd.
Crashing the router on user's wish.	**test crash**	This is a hidden Cisco IOS command to crash the Cisco router on a user's wish.	Router#**test crash**	Potential enough to flap bfd.
License EULA	**license accept end user agreement**	To accept the End-user License Agreement (EULA) for all Cisco IOS software packages and features at one time.	Router(config)#**license accept end user agreement**	Potential enough to flap bfd.
RTC Battery Failure	No CLI	Write the event of losing battery for Real Time Clock.	No CLI	Potential enough to flap bfd. **Note** This is a one-time event during a hardware failure.
Erasing NV memory.	**erase nvram**	This command erases the nvram: file system.	Router#**erase nvram:**	Potential enough to flap bfd.
Erasing startup-config	**erase startup-config**	This command erases startup configurations.	Router#**erase startup-config**	Potential enough to flap bfd.
Erasing NV memory.	**write erase**	This command erases the NV memory.	Router#**write erase**	Potential enough to flap bfd.
Writing configuration to memory.	**write**	This command quickly saves config to memory.	Router#**write**	Potential enough to flap bfd.

Table 7 Cisco IOS Commands

Functionality	Command Name	Description	Configuration Example	Impact
Reloading the router.	**reload**	This command reloads the router. The reload time is written to NV memory.	Router#**reload**	Potential enough to flap bfd.
Enabling warm rebooting.	**warm-reboot count** *value* **uptime** *value*	Enables a router to warm-reboot.	Router(config)# **warm-reboot count 10 uptime 10**	Potential enough to flap bfd.
New software license boot.	**license boot module module-name level license-level**	To boot a new software license on routing platforms, use the license boot module command in global configuration mode.	Router(config)# **license boot module c2900 technology-package datak9**	Potential enough to flap bfd.
Enabling or disabling USB ports.	**config mode : hw-module usb**	Enable or disable USB ports from IOS config mode.	Router(config)#**hw-module usb disable** Router(config)#**no hw-module usb disable**	Will trigger a BFD flap.
Disabling access to ROMMON.	**[no] service password-recovery**	This command disables all access to ROMMON.	Router# **no service password-recovery**	Potential enough to flap bfd.

Basic Router Configuration

This module provides configuration procedures for Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series integrated services routers (ISRs). It also includes configuration examples and verification steps whenever possible.

Note See Appendix A, "Cisco IOS CLI for Initial Configuration" for information on how to perform the initial configuration using the Cisco Internet Operating System (IOS) command line interface on Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series integrated services routers.

Basic Configuration

- Default Configuration, page 14
- Configuring Global Parameters, page 15

Interface Configuration

- Interface Ports, page 17
- Configuring Gigabit Ethernet Interfaces, page 18
- Configuring Wireless LAN Interfaces, page 19
- Configuring Interface Card and Module Interfaces, page 19
- Configuring a Loopback Interface, page 19

Routing Configuration

- Configuring Command-Line Access, page 21
- Configuring Static Routes, page 23
- Configuring Dynamic Routes, page 25

Default Configuration

When you boot up your Cisco router for the first time, you notice some basic configuration has already been performed. Use the **show running-config** command to view the initial configuration, as shown in the following example.

```
Router# show running-config
Building configuration...
Current configuration : 723 bytes
!
version 12.4
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Router
!
boot-start-marker
boot-end-marker
!
logging message-counter syslog
!
no aaa new-model
!
no ipv6 cef
ip source-route
ip cef
!
!
!
!
multilink bundle-name authenticated
!
!
archive
 log config
  hidekeys
!
!
!
!
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/2
 no ip address
 shutdown
 duplex auto
 speed auto
!
ip forward-protocol nd
```

```
!
no ip http server
!
!
!
!
!
control-plane
!
!
line con 0
line aux 0
line vty 0 3
 login
!
exception data-corruption buffer truncate
scheduler allocate 20000 1000
end
```

Configuring Global Parameters

To configure the global parameters for your router, follow these steps.

SUMMARY STEPS

1. **configure terminal**
2. **hostname** *name*
3. **enable secret** *password*
4. **no ip domain-lookup**

DETAILED STEPS

	Command	Purpose

Step 1	**configure terminal**
	
	Example:
	`Router> enable`
	`Router# configure terminal`
	`Router(config)#`
		Enters global configuration mode, when using the console port.
		
		Use the following to connect to the router with a remote terminal:
		`telnet router name or address`
		`Login: login id`
		`Password: *********`
		`Router> enable`

Step 2	**hostname** *name*
	
	Example:
	`Router(config)# hostname Router`
	`Router(config)#`
		Specifies the name for the router.

	Command	Purpose

Step 3	**enable secret** *password*
	
	Example:
	`Router(config)# enable secret cr1ny5ho`
	`Router(config)#`
		Specifies an encrypted password to prevent unauthorized access to the router.

Step 4	**no ip domain-lookup**
	
	Example:
	`Router(config)# no ip domain-lookup`
	`Router(config)#`
		Disables the router from translating unfamiliar words (typos) into IP addresses.

For complete information on global parameter commands, see the Cisco IOS Release configuration guide documentation set.

Configuring I/O Memory Allocation

To reallocate the percentage of DRAM in use for I/O memory and processor memory on Cisco 3925E and Cisco 3945E routers, use the **memory-size iomem** *i/o-memory-percentage* command in global configuration mode. To revert to the default memory allocation, use the **no** form of this command. This procedure enables **smartinit**.

Syntax	Description
i/o-memory-percentage	The percentage of DRAM allocated to I/O memory. The values permitted are 5, 10, 15, 20, 25, 30, 40, and 50. A minimum of 201 MB of memory is required for I/O memory.

Tip We recommend that you configure the memory-size iomem below 25%. Any value above 25% should be used only for enhancing IPSec performance.

When you specify the percentage of I/O memory in the command line, the processor memory automatically acquires the remaining percentage of DRAM memory.

Example

The following example allocates 25% of the DRAM memory to I/O memory and the remaining 75% to processor memory:

```
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# memory-size iomem 5
IO memory size too small:  minimum IO memory size is 201M
Router(config)#
Router(config)# memory-size iomem ?
<5-50>  percentage of DRAM to use for I/O memory: 5, 10, 15, 20, 25, 30, 40, 50

Router(config)# memory-size iomem 25
Smart-init will be disabled and new I/O memory size will take effect upon reload.
Router(config)# end
```

Verifying IOMEM Setting

```
Router# show run
Current configuration : 6590 bytes
!
! Last configuration change at 16:48:41 UTC Tue Feb 23 2010 !
version 15.1
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
service internal
!
hostname Router1
!
!
no aaa new-model
!
memory-size iomem 25
!
```

Interface Ports

Table 1 lists the interfaces that are supported on Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series integrated services routers.

Table 1 Interfaces by Cisco Router

Slots, Ports, Logical Interface, Interfaces	1941	2901[1]	2911 & 2921	2951 & 3925 & 3945	3925E & 3945E
Onboard GE ports	Gi0/0,Gi0/1	Gi0/0,Gi0/1	Gi0/0,Gi0/1,GI0/2	Gi0/0,Gi0/1,GI0/2	Gi0/0,Gi0/1,GI0/2, GI0/3
Onboard WLAN	Wlan-ap0	not supported	not supported	not supported	not supported
Onboard WLAN GE connection to MGF[2]	Wlan-Gi0/0	not supported	not supported	not supported	not supported
Onboard ISM GE interface on the PCIe	*service-module-name*-ISM 0/0	*service-module-name*-ISM 0/0	*service-module-name*-ISM 0/0	*service-module-name*-ISM 0/0	not supported
Onboard ISM GE connection to MGF	*service-module-name*-ISM 0/1	*service-module-name*-ISM 0/1	*service-module-name*-ISM 0/1	*service-module-name*-ISM 0/1	not supported
USB	*usbflash0, usbflash1* *usbtoken0, usbtoken1*	*usbflash0, usbflash1* *usbtoken0, usbtoken1*	*usbflash0, usbflash1* *usbtoken0, usbtoken1*	*usbflash0, usbflash1* *usbtoken0, usbtoken1*	*usbflash0, usbflash1* *usbtoken0, usbtoken1*
Interfaces on HWIC and VWIC	*interface*0/0/*port* *interface*0/1/*port*	*interface*0/0/*port* *interface*0/1/*port* *interface*0/2/*port* *interface* 0/3/*port*	*interface*0/0/*port* *interface*0/1/*port* *interface*0/2/*port* *interface* 0/3/*port*	*interface*0/0/*port* *interface*0/1/*port* *interface*0/2/*port* *interface* 0/3/*port*	<int>0/0/<port> <int>0/1/<port> <int>0/2/<port>
Interfaces on Double Wide-HWIC	*interface*0/1 *port*	*interface*0/1/*port* *interface*0/3/*port*	*interface*0/1/*port* *interface*0/3/*port*	*interface*0/1/*port* *interface*0/3/*port*	<int>0/1/<port>
Interfaces on SM	not supported	not supported	*interface*1/*port*	*interface1-2/port*[3] *interface1-4/port*[4]	*interface*1-2/*port* *interface*1-4/*port*

Table 1 Interfaces by Cisco Router (continued)

Slots, Ports, Logical Interface, Interfaces	1941	2901[1]	2911 & 2921	2951 & 3925 & 3945	3925E & 3945E
Interfaces on Double Wide-SM	not supported	not supported	not supported	*interface 2/port*[5] *interface4/port*[6]	*interface* 2/*port* *interface* 4/*port*
Interfaces HWIC on SM Interfaces VWIC on SM	not supported	not supported	*interface1wic-slot/ port*	*interface1-2/wic-slot/port*[7] *interface1-4/wic-slot/port*[8]	*interface1-2/wic-slot/port* *interface1-4/wic-slot/port*

1. On the Cisco 2901 router, the numbering format for configuring an asynchronous interface is 0/slot/port. To configure the line associated with an asynchronous interface, simply use the interface number to specify the asynchronous line. For example, line 0/1/0 specifies the line associated with interface serial 0/1/0 on a WIC-2A/S in slot 1. Similarly, line 0/2/1 specifies the line associated with interface async 0/2/1 on a WIC-2AM in slot 2.
2. MGF = multi-gigabit fabric
3. Applies only to Cisco 2951, Cisco 3925, and Cisco 3925E routers.
4. Applies only to Cisco 3945 and Cisco 3945E routers.
5. Applies only to Cisco 2951, Cisco 3925, and Cisco 3925E routers.
6. Applies only to Cisco 3945 and Cisco 3945E routers.
7. Applies only to Cisco 2951, Cisco 3925, and Cisco 3925E routers.
8. Applies only to Cisco 3945 and Cisco 3945E routers.

Configuring Gigabit Ethernet Interfaces

To manually define onboard Gigabit Ethernet (GE) interfaces, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **interface gigabitethernet** *slot/port*
2. **ip address** *ip-address mask*
3. **no shutdown**
4. **exit**

DETAILED STEPS

	Command	Purpose

Step 1	**interface gigabitethernet** *slot/port*
	Example:
	`Router(config)# interface gigabitethernet 0/1`
	`Router(config-if)#`
		Enters the configuration mode for a Gigabit Ethernet interface on the router.

Step 2	**ip address** *ip-address mask*
	Example:
	`Router(config-if)# ip address 192.168.12.2 255.255.255.0`
	`Router(config-if)#`
		Sets the IP address and subnet mask for the specified GE interface.

	Command	Purpose

Step 3	**no shutdown**
	
	Example:
	`Router(config-if)# no shutdown`
	`Router(config-if)#`
		Enables the GE interface, changing its state from administratively down to administratively up.

Step 4	**exit**
	
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits configuration mode for the GE interface and returns to global configuration mode.

Configuring Wireless LAN Interfaces

The wireless LAN interface on the Cisco 1941W router enables connection to the router through **interface wlan-ap0**. For more information about configuring a wireless connection, see the "Configuring the Wireless Device" section on page 243.

Configuring Interface Card and Module Interfaces

To configure interface cards and modules inserted in internal services module (ISM), enhanced high-speed WAN interface card (EHWIC), Ethernet WAN interface card (EWIC), and service module (SM) slots, see the appropriate interface card or module configuration documents on Cisco.com.

Configuring a Loopback Interface

The loopback interface acts as a placeholder for the static IP address and provides default routing information.

For complete information on the loopback commands, see the Cisco IOS Release configuration guide documentation set.

To configure a loopback interface, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **interface** *type number*
2. **ip address** *ip-address mask*
3. **exit**

DETAILED STEPS

	Command	Purpose

Step 1	**interface** *type number*
	
	Example:
	`Router(config)# interface Loopback 0`
	`Router(config-if)#`
		Enters configuration mode for the loopback interface.

Step 2	**ip address** *ip-address mask*
	
	Example:
	`Router(config-if)# ip address 10.108.1.1 255.255.255.0`
	`Router(config-if)#`
		Sets the IP address and subnet mask for the loopback interface.

Step 3	**exit**
	
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits configuration mode for the loopback interface and returns to global configuration mode.

Example

The loopback interface in this sample configuration is used to support Network Address Translation (NAT) on the virtual-template interface. This configuration example shows the loopback interface configured on the gigabit ethernet interface with an IP address of 200.200.100.1/24, which acts as a static IP address. The loopback interface points back to virtual-template1, which has a negotiated IP address.

```
!
interface loopback 0
ip address 200.200.100.1 255.255.255.0 (static IP address)
ip nat outside
!
interface Virtual-Template1
ip unnumbered loopback0
no ip directed-broadcast
ip nat outside
!
```

Verifying Configuration

To verify that you have properly configured the loopback interface, enter the **show interface loopback** command. You should see verification output similar to the following example.

```
Router# show interface loopback 0
Loopback0 is up, line protocol is up
  Hardware is Loopback
  Internet address is 200.200.100.1/24
  MTU 1514 bytes, BW 8000000 Kbit, DLY 5000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation LOOPBACK, loopback not set
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy: fifo
  Output queue 0/0, 0 drops; input queue 0/75, 0 drops
```

```
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 packets output, 0 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 output buffer failures, 0 output buffers swapped out
```

Another way to verify the loopback interface is to ping it:

```
Router# ping 200.200.100.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 200.200.100.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
```

Configuring Command-Line Access

To configure parameters to control access to the router, follow these steps, beginning in global configuration mode.

Note The TTY lines are asynchronous lines used for inbound or outbound modem and terminal connections and can be seen in a router or access server configuration as line *x*. The specific line numbers are a function of the hardware built into or installed on the router or access server. In Cisco ISR G2 series routers, the TTY lines are incremented by 1 and start with line number3 instead of line number 2 in Cisco ISR G1 series routers. In ISR G2 series routers, line number 2 cannot be accessed since it has been used for the second core feature.TTY lines are not static and line numbers can be changed in future when more features are added similar to the second core.

SUMMARY STEPS

1. **line** [**aux** | **console** | **tty** | **vty**] *line-number*
2. **password** *password*
3. **login**
4. **exec-timeout** *minutes* [*seconds*]
5. **line** [**aux** | **console** | **tty** | **vty**] *line-number*
6. **password** *password*
7. **login**
8. **end**

DETAILED STEPS

	Command	Purpose

Step 1	**line** [**aux** | **console** | **tty** | **vty**] *line-number*
	
	Example:
	`Router(config)# line console 0`
	`Router(config-line)#`
		Enters line configuration mode, and specifies the type of line.
		
		This example specifies a console terminal for access.

Step 2	**password** *password*
	
	Example:
	`Router(config-line)# password 5dr4Hepw3`
	`Router(config-line)#`
		Specifies a unique password for the console terminal line.

Step 3	**login**
	
	Example:
	`Router(config-line)# login`
	`Router(config-line)#`
		Enables password checking at terminal session login.

Step 4	**exec-timeout** *minutes* [*seconds*]
	
	Example:
	`Router(config-line)# exec-timeout 5 30`
	`Router(config-line)#`
		Sets the interval that the EXEC command interpreter waits until user input is detected. The default is 10 minutes. Optionally, add seconds to the interval value.
		
		This example shows a timeout of 5 minutes and 30 seconds. Entering a timeout of 0 0 specifies never to time out.

Step 5	**line** [**aux** | **console** | **tty** | **vty**] *line-number*
	
	Example:
	`Router(config-line)# line vty 0 4`
	`Router(config-line)#`
		Specifies a virtual terminal for remote console access.

Step 6	**password** *password*
	
	Example:
	`Router(config-line)# password aldf2ad1`
	`Router(config-line)#`
		Specifies a unique password for the virtual terminal line.

Step 7	**login**
	
	Example:
	`Router(config-line)# login`
	`Router(config-line)#`
		Enables password checking at the virtual terminal session login.

Step 8	**end**
	
	Example:
	`Router(config-line)# end`
	`Router#`
		Exits line configuration mode, and returns to privileged EXEC mode.

Example

The following configuration shows the command-line access commands.

You do not need to input the commands marked "default." These commands appear automatically in the configuration file generated when you use the **show running-config** command.

```
!
line con 0
exec-timeout 10 0
password 4youreyesonly
login
transport input none (default)
stopbits 1 (default)
line vty 0 4
password secret
login
!
```

Configuring Static Routes

Static routes provide fixed routing paths through the network. They are manually configured on the router. If the network topology changes, the static route must be updated with a new route. Static routes are private routes unless they are redistributed by a routing protocol.

To configure static routes, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **ip route** *prefix mask* {*ip-address* | *interface-type interface-number* [*ip-address*]}
2. **end**

DETAILED STEPS

	Command	Purpose

Step 1	**ip route** *prefix mask* {*ip-address* | *interface-type interface-number* [*ip-address*]}
	
	Example:
	`Router(config)# ip route 192.168.1.0 255.255.0.0 10.10.10.2`
	`Router(config)#`
		Specifies the static route for the IP packets.
		
		For details about this command and about additional parameters that can be set, see *Cisco IOS IP Command Reference, Volume 2 of 4: Routing Protocols, Release 12.3*

Step 2	**end**
	
	Example:
	`Router(config)# end`
	`Router#`
		Exits router configuration mode, and enters privileged EXEC mode.

Example

In the following configuration example, the static route sends out all IP packets with a destination IP address of 192.168.1.0 and a subnet mask of 255.255.255.0 on the Gigabit Ethernet interface to another device with an IP address of 10.10.10.2. Specifically, the packets are sent to the configured PVC.

You do not need to enter the command marked "(**default**)." This command appears automatically in the configuration file generated when you use the **show running-config** command.

```
!
ip classless (default)
ip route 192.168.1.0 255.255.255.0 10.10.10.2!
```

Verifying Configuration

To verify that you have properly configured static routing, enter the **show ip route** command and look for static routes signified by the "S."

You should see verification output similar to the following:

```
Router# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 1 subnets
C       10.108.1.0 is directly connected, Loopback0
S* 0.0.0.0/0 is directly connected, FastEthernet0
```

Configuring Dynamic Routes

In dynamic routing, the network protocol adjusts the path automatically, based on network traffic or topology. Changes in dynamic routes are shared with other routers in the network.

The Cisco routers can use IP routing protocols, such as Routing Information Protocol (RIP) or Enhanced Interior Gateway Routing Protocol (EIGRP), to learn routes dynamically. You can configure either of these routing protocols on your router.

- "Configuring Routing Information Protocol" section on page 25
- "Configuring Enhanced Interior Gateway Routing Protocol" section on page 27

Configuring Routing Information Protocol

To configure the RIP routing protocol on the router, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **router rip**
2. **version** {**1** | **2**}
3. **network** *ip-address*
4. **no auto-summary**
5. **end**

DETAILED STEPS

	Command	Task

Step 1	**router rip**
	
	Example:
	`Router> configure terminal`
	`Router(config)# router rip`
	`Router(config-router)#`
		Enters router configuration mode, and enables RIP on the router.

Step 2	**version** {**1** | **2**}
	
	Example:
	`Router(config-router)# version 2`
	`Router(config-router)#`
		Specifies use of RIP version 1 or 2.

Step 3	**network** *ip-address*
	
	Example:
	`Router(config-router)# network 192.168.1.1`
	`Router(config-router)# network 10.10.7.1`
	`Router(config-router)#`
		Specifies a list of networks on which RIP is to be applied, using the address of the network of each directly connected network.

Step 4	**no auto-summary**
	
	Example:
	`Router(config-router)# no auto-summary`
	`Router(config-router)#`
		Disables automatic summarization of subnet routes into network-level routes. This allows subprefix routing information to pass across classful network boundaries.

Step 5	**end**
	
	Example:
	`Router(config-router)# end`
	`Router#`
		Exits router configuration mode, and enters privileged EXEC mode.

Example

The following configuration example shows RIP version 2 enabled in IP network 10.0.0.0 and 192.168.1.0.

To see this configuration, use the **show running-config** command from privileged EXEC mode.

```
!
Router# show running-config
router rip
 version 2
 network 10.0.0.0
 network 192.168.1.0
 no auto-summary
!
```

Verifying Configuration

To verify that you have properly configured RIP, enter the **show ip route** command and look for RIP routes signified by "R." You should see a verification output like the example shown below.

```
Router# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 1 subnets
C       10.108.1.0 is directly connected, Loopback0
R    3.0.0.0/8 [120/1] via 2.2.2.1, 00:00:02, Ethernet0/0
```

Configuring Enhanced Interior Gateway Routing Protocol

To configure Enhanced Interior Gateway Routing Protocol GRP (EGRP), follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **router eigrp** *as-number*
2. **network** *ip-address*
3. **end**

DETAILED STEPS

	Command	Purpose

Step 1	**router eigrp** *as-number*
	
	Example:
	`Router(config)# router eigrp 109`
	`Router(config)#`
		Enters router configuration mode, and enables EIGRP on the router. The autonomous-system number identifies the route to other EIGRP routers and is used to tag the EIGRP information.

Step 2	**network** *ip-address*
	
	Example:
	`Router(config)# network 192.145.1.0`
	`Router(config)# network 10.10.12.115`
	`Router(config)#`
		Specifies a list of networks on which EIGRP is to be applied, using the IP address of the network of directly connected networks.

Step 3	**end**
	
	Example:
	`Router(config-router)# end`
	`Router#`
		Exits router configuration mode, and enters privileged EXEC mode.

Example

The following configuration example shows the EIGRP routing protocol enabled in IP networks 192.145.1.0 and 10.10.12.115. The EIGRP autonomous system number is 109.

To see this configuration use the **show running-config** command, beginning in privileged EXEC mode.

```
Router# show running-config
...
!
router eigrp 109
    network 192.145.1.0
        network 10.10.12.115
!
...
```

Verifying Configuration

To verify that you have properly configured IP EIGRP, enter the **show ip route** command, and look for EIGRP routes indicated by "D." You should see verification output similar to the following:

```
Router# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 1 subnets
C       10.108.1.0 is directly connected, Loopback0
D    3.0.0.0/8 [90/409600] via 2.2.2.1, 00:00:02, Ethernet0/0
```

Configuring Ethernet CFM and Y.1731 Performance Monitoring on Layer 3 Interfaces

This chapter provides procedures for configuring the network interface device functionality, Ethernet data plane loopback, IEEE connectivity fault management, and Y.1731 performance monitoring, and contains the following sections:

- Configuring a Network Interface Device on the L3 Interface, page 29
- Ethernet Data Plane Loopback, page 32
- CFM Support on Routed Port and Port MEP, page 38
- Support for Y.1731 Performance Monitoring on a Routed Port (L3 Subinterface), page 54

Configuring a Network Interface Device on the L3 Interface

Configuring a Network Interface Device (NID) enables support for the NID functionality on the router without including a NID hardware in the network. This feature combines the Customer-Premises Equipment (CPE) and the NID functionality into a physical device. The following are the advantages of configuring the NID functionality:

- Eliminates a physical device.
- Supports both the managed CPE feature set and the NID requirements.

Note This feature is supported only if you have purchased the DATA technology package functionality (*datak9*) licensing package. For more information about managing software activation licenses on the Cisco ISR and Cisco ISR G2 platforms, see http://www.cisco.com/en/US/docs/routers/access/sw_activation/SA_on_ISR.html.

Configuring the NID

The following steps describe how to configure the NID:

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **interface gigabitethernet** *slot/port*

Step 4 **port-tagging**

Step 5 **encapsulation dot1q** *vlan-id*

Step 6 **set cos** *cos-value*

Step 7 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router>enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router#configure terminal`	Enters the global configuration mode.
Step 3	**interface gigabitethernet** *slot/port* **Example:** `Router(config)#interface gigabitethernet 0/2`	Specifies an interface and enters the interface configuration mode.
Step 4	**port-tagging** **Example:** `Router(config-if)#port-tagging`	Inserts the VLAN ID into a packet header to identify which Virtual Local Area Network (VLAN) the packet belongs to.
Step 5	**encapsulation dot1q** *vlan-id* **Example:** `Router(config-if-port-tagging)#encapsulation dot1q 10`	Defines the encapsulation format as IEEE 802.1Q (dot1q), and specifies the VLAN identifier.
Step 6	**set cos** *cos-value* **Example:** `Router(config-if-port-tagging)#set cos 6`	Sets the Layer 2 class of service (CoS) value to an outgoing packet end.
Step 7	**end** **Example:** `Router(config-if-port-tagging)#end`	Exits the interface configuration mode.

Configuration Example

This configuration example shows how to configure the NID:

```
Router>enable
Router#configure terminal
Router(config)#interface gigabitethernet 0/2
Router(config-if)#port-tagging
Router(config-if-port-tagging)#encapsulation dot1q 10
Router(config-if-port-tagging)#set cos 6
Router(config-if-port-tagging)#end
```

Verifying the NID Configuration

Use the following commands to verify the port tagging sessions:

- **show run int**
- **ping**

Use the **show run int** command to display the port tagging sessions:

```
Router#show run int gi0/2
Building configuration...
Current configuration : 10585 bytes
!
interface GigabitEthernet0/2
 no ip address
 duplex auto
 speed auto
 port-tagging
  encapsulation dot1q 10
  set cos 6
  exit
end
!
interface GigabitEthernet0/2.1101
encapsulation dot1Q 100
ip address 132.1.101.4 255.255.255.0
!
interface GigabitEthernet0/2.1102
encapsulation dot1Q 100
ip address 132.1.102.4 255.255.255.0
!
```

Use the **ping** command to verify the connectivity with port tagging configured:

```
Router#ping 132.1.101.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 132.1.101.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
router#
```

Troubleshooting the NID Configuration

Table 1 lists the debug commands to troubleshoot the issues pertaining to the NID functionality.

The Cisco IOS Master Command List at

http://www.cisco.com/en/US/docs/ios/mcl/allreleasemcl/all_book.html provides more information about these commands.

Caution Because debugging output is assigned high priority in the CPU process, it can diminish the performance of the router or even render it unusable. For this reason, use debug commands only to troubleshoot specific problems or during troubleshooting sessions with Cisco technical support staff.

Note Before you run any of the debug commands listed in the following table, ensure that you run the **logging buffered debugging** command, and then turn off console debug logging using the **no logging console** command.

Table 1 debug Commands for NID Configuration

debug Command	Purpose
debug ethernet nid configuration	Enables debugging of configuration-related issues.
debug ethernet nid packet egress	Enables debugging of packet processing (VLAN tag push) on the egress side.
debug ethernet nid packet ingress	Enables debugging of packet processing (VLAN tag pop) on the ingress side.

Ethernet Data Plane Loopback

The Ethernet Data Plane Loopback feature provides a means for remotely testing the throughput of an Ethernet port. You can verify the maximum rate of frame transmission with no frame loss.

Note This feature is supported only if you have purchased the DATA technology package functionality (*datak9*) licensing package. For more information about managing software activation licenses on the Cisco ISR and Cisco ISR G2 platforms, see http://www.cisco.com/en/US/docs/routers/access/sw_activation/SA_on_ISR.html.

Note Internal Ethernet data plane loopback is not supported.

Restrictions for Configuring External Ethernet Data Plane Loopback

Follow the guidelines and take note of the restrictions listed here when configuring Ethernet data plane loopback on a Layer 3 interface:

- Only external loopback (packets coming from the wire side) on the L3 dot1q subinterface and (untagged) main interface are supported.
- To perform a MAC swap, the destination address and source address must be swapped for the packets that are looped back. If the destination address is broadcast or multicast, the MAC address is used as the source address for the packets that are looped back.
- Loopback operations are supported at line rate.
- Untagged frames are not supported on a subinterface. However, the frames for *dot1q* and *qinq* are supported on a subinterface.

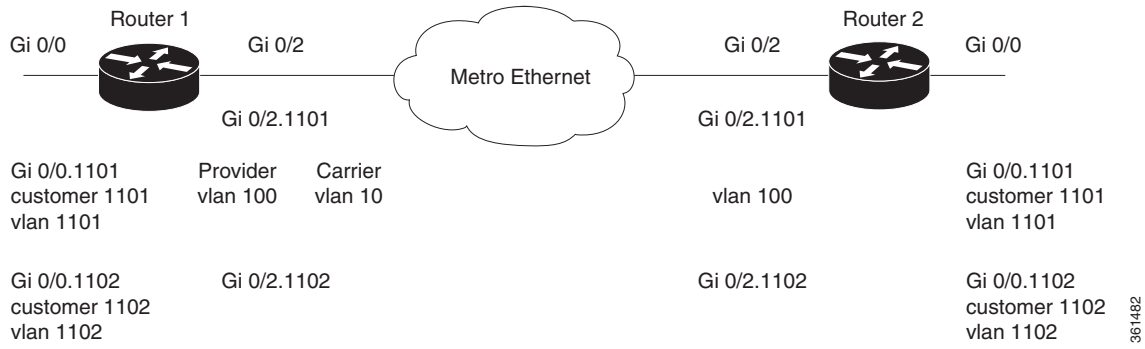
- *dot1ad* is not supported on the main interface. However, untagged frames are supported on the main interface.
- Single VLAN is supported as a filtering option for a subinterface, but VLAN list and VLAN range are not supported.
- Only MAC address is supported as a filtering option for the main interface.
- For the filtering option, the destination MAC cannot be combined with inner VLAN or outer VLAN.
- There is no support for L3 and L4 loopback. Source and destination IP address or source and destination ports will not be swapped.
- Connectivity Fault Management (CFM) packets are transparent to the data plane loopback configuration and cannot be looped back.
- Packets coming from the other side of the wire where loopback is configured and having the same destination MAC address are dropped.
- The broadcast and multicast IP addresses of the broadcast and multicast IP frames that are received cannot be used as the source IP address of the frame when it is sent back to the initiator. In such a case, the IP address of the subinterface is used as the source IP address of the frame when it is sent back to the initiator.

Configuring External Ethernet Data Plane Loopback

Configuring external Ethernet data plane loopback is permitted on a Layer 3 main interface and subinterfaces.

Figure 1 represents a sample topology to configure Ethernet data plane loopback.

Figure 1 Sample Topology



The following steps show how to configure external Ethernet data plane loopback on a subinterface using single and double tagging. (The procedure to configure external Ethernet data plane loopback on the main interface is similar to this procedure.)

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **interface gigabitethernet** *slot/port.sub-port*

Step 4 **encapsulation dot1q** *vlan-id*

or

encapsulation dot1q *vlan-id* **second-dot1q** *inner vlan-id*

Step 5 **ethernet loopback permit external**

Step 6 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router>enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router#configure terminal`	Enters the global configuration mode.
Step 3	**interface gigabitethernet** *slot/port.sub-port* **Example:** `Router(config)#interface gigabitethernet 0/2.1101`	Specifies the subinterface and enters the subinterface configuration mode.

Step 4	**encapsulation dot1q** *vlan-id*
	
	or
	
	encapsulation dot1q *vlan-id* **second-dot1q** *inner vlan-id*
	
	Example:
	`Router(config-subif)#encapsulation dot1q 100`
	or
	`Router(config-subif)#encapsulation dot1q 100 second-dot1q 1101`
		Defines the encapsulation format as IEEE 802.1Q (dot1q), and specifies the VLAN identifier.
		For double tagging, use the **second-dot1q** keyword and the *inner vlan-id* argument to specify the VLAN tag.

Step 5	**ethernet loopback permit external** **Example:** `Router(config-subif)#ethernet loopback permit external`	Configures Ethernet external loopback on the subinterface.
Step 6	**end** **Example:** `Router(config-subif)#end`	Exits the subinterface configuration mode.

To start Ethernet data plane loopback, run the following command:

	Command	Purpose
Step 1	**ethernet loopback start local interface gigabitethernet** *slot/port.sub-port* **external timeout** *none* **Example:** `Router#ethernet loopback start local interface gigabitethernet 0/2.1101 external timeout none`	Starts Ethernet external loopback on a subinterface. Enter timeout as *none* to have no time out period for the loopback.

To stop Ethernet data plane loopback, perform the following steps:

	Command	Purpose
Step 1	**ethernet loopback stop local interface gigabitethernet** *slot/port.sub-port* **id** *session-id* **Example:** `Router#ethernet loopback stop local interface gigabitethernet 0/2.1101 id 1`	Stops Ethernet external loopback on a subinterface. Enter the value of the loopback session ID to specify the loopback session that you want to stop.
Step 2	**show ethernet loopback active** **Example:** `Router#show ethernet loopback active`	Displays information to verify if the loopback session has ended.

Configuration Examples for Ethernet Data Plane Loopback

This example shows how to configure Ethernet data plane loopback using single tagging:

```
Router>enable
Router#configure terminal
Router(config)#interface gigabitethernet 0/2.1101
Router(config-subif)#encapsulation dot1q 100
Router(config-subif)#ethernet loopback permit external
Router(config-subif)#end
```

This example shows how to configure Ethernet data plane loopback using double tagging:

```
Router>enable
Router#configure terminal
Router(config)#interface gigabitethernet 0/2.1101
Router(config-subif)#encapsulation dot1q 100 second-dot1q 1101
Router(config-subif)#ethernet loopback permit external
Router(config-subif)#end
```

This example shows how to start an Ethernet data plane loopback:

```
Router#ethernet loopback start local interface gigabitethernet 0/2.1101 external timeout
none
```

```
This is an intrusive loopback and the packets matched with the service will not be able to
pass through. Continue? (yes/[no]):
```

Enter `yes` to continue.

This example shows how to stop an Ethernet data plane loopback:

```
Router#ethernet loopback stop local interface gigabitethernet 0/2.1101 id 1
Router#*Oct 21 10:16:17.887: %E_DLB-6-DATAPLANE_LOOPBACK_STOP: Ethernet Dataplane Loopback
Stop on interface GigabitEthernet0/2 with session id 1
Router#show ethernet loopback active
Total Active Session(s): 0
Total Internal Session(s): 0
Total External Session(s): 0
```

Verifying the Ethernet Data Plane Loopback Configuration

Use the following commands to verify the Ethernet data plane loopback configuration:

- **show ethernet loopback permitted**
- **show ethernet loopback active**

Use the **show ethernet loopback permitted** command to view the loopback capabilities per interface:

```
Router#show ethernet loopback permitted
------------------------------------------------------------------------------
Interface                               SrvcInst Direction
Dot1q/Dot1ad(s)                         Second-Dot1q(s)
------------------------------------------------------------------------------
Gi0/2.1101                              N/A      External
100                                     1101
```

Use the **show ethernet loopback active** command to display the summary of the active loopback sessions on a subinterface:

```
Router#show ethernet loopback active
Loopback Session ID     : 1
Interface               : GigabitEthernet0/2.1101
Service Instance        : N/A
Direction               : External
Time out(sec)           : none
Status                  : on
Start time              : *10:17:46.930 UTC Mon Oct 21 2013
Time left               : N/A
Dot1q/Dot1ad(s)         : 100
Second-dot1q(s)         : 1101
Source Mac Address      : Any
Destination Mac Address : Any
Ether Type              : Any
Class of service        : Any
Llc-oui                 : Any


Total Active Session(s): 1
Total Internal Session(s): 0
Total External Session(s): 1
```

Use the **show ethernet loopback active** command to display the summary of the active loopback sessions on the main interface:

```
Router#show ethernet loopback permitted
Loopback Session ID     : 1
Interface               : GigabitEthernet0/2
```

```
Service Instance        : N/A
Direction               : External
Time out(sec)           : none
Status                  : on
Start time              : *10:14:23.507 UTC Mon Oct 21 2013
Time left               : N/A
Dot1q/Dot1ad(s)         : 1-100
Second-dot1q(s)         : 1-1101
Source Mac Address      : Any
Destination Mac Address : Any
Ether Type              : Any
Class of service        : Any
Llc-oui                 : Any


Total Active Session(s): 1
Total Internal Session(s): 0
Total External Session(s): 1
```

Troubleshooting the Ethernet Data Plane Loopback Configuration

Table 2 lists the debug commands to troubleshoot issues pertaining to the Ethernet Data Plane Loopback feature.

The Cisco IOS Master Command List at

http://www.cisco.com/en/US/docs/ios/mcl/allreleasemcl/all_book.html provides more information about these commands.

Caution Because debugging output is assigned high priority in the CPU process, it can diminish the performance of the router or even render it unusable. For this reason, use debug commands only to troubleshoot specific problems or during troubleshooting sessions with Cisco technical support staff.

Note Before you run any of the debug commands listed in the following table, ensure that you run the **logging buffered debugging** command, and then turn off console debug logging using the **no logging console** command.

Table 2 debug Commands for Ethernet Data Plane Loopback Configuration

debug Command	Purpose
debug elb-pal-pd all	Displays all the debugging information about the Ethernet data plane loopback configuration.
debug elb-pal-pd error	Displays debugging information about Ethernet data plane loopback configuration errors.
debug elb-pal-pd event	Displays debugging information about Ethernet data plane loopback configuration changes.

CFM Support on Routed Port and Port MEP

IEEE Connectivity Fault Management (CFM) is an end-to-end per-service Ethernet-layer Operations, Administration, and Maintenance (OAM) protocol. CFM includes proactive connectivity monitoring, fault verification, and fault isolation for large Ethernet metropolitan-area networks (MANs) and WANs.

Note This feature is supported only if you have purchased the DATA technology package functionality (*datak9*) licensing package. For more information about managing software activation licenses on the Cisco ISR and Cisco ISR G2 platforms, see http://www.cisco.com/en/US/docs/routers/access/sw_activation/SA_on_ISR.html.

Restrictions for Configuring Ethernet CFM

- A specific domain must be configured. If it is not, an error message is displayed.
- Multiple domains (different domain names) having the same maintenance level can be configured. However, associating a single domain name with multiple maintenance levels is not permitted.

Configuring Ethernet CFM (Port MEP)

Complete these steps to configure and enable Ethernet CFM on a port Maintenance End Point (MEP):

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **ethernet cfm ieee**

Step 4 **ethernet cfm global**

Step 5 **ethernet cfm domain** *domain-name* **level** *value*

Step 6 **service** *service-name* **port**

Step 7 **continuity-check interval** *value*

Step 8 **end**

Step 9 **configure terminal**

Step 10 **interface gigabitethernet** *slot/port*

Step 11 **ethernet cfm mep domain** *domain-name* **mpid** *mpid-value* **service** *service-name*

Step 12 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router>enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router#configure terminal`	Enters the global configuration mode.
Step 3	**ethernet cfm ieee** **Example:** `Router(config)#ethernet cfm ieee`	Enables the IEEE version of CFM.
Step 4	**ethernet cfm global** **Example:** `Router(config)#ethernet cfm global`	Enables CFM processing globally on the router.
Step 5	**ethernet cfm domain** *domain-name* **level** *value* **Example:** `Router(config-ecfm)#ethernet cfm domain carrier level 2`	Defines a CFM maintenance domain at a specified level, and enters the Ethernet CFM configuration mode. **level** can be any value from 0 to 7.
Step 6	**service** *service-name* **port** **Example:** `Router(config-ecfm)#service carrier port`	Creates a service on the interface and sets the *config-ecfm-srv* submode.
Step 7	**continuity-check interval** *value* **Example:** `Router(config-ecfm-srv)#continuity-check interval 100m`	Enables sending continuity check messages at the set interval.
Step 8	**end** **Example:** `Router(config-ecfm-srv)#end`	Returns the router to the privileged EXEC mode.
Step 9	**configure terminal** **Example:** `Router#configure terminal`	Enters the global configuration mode.

	Command	Purpose
Step 10	**interface gigabitethernet** *slot/port* **Example:** `Router(config)#interface gigabitethernet 0/2`	Specifies an interface and enters the interface configuration mode.
Step 11	**ethernet cfm mep domain** *domain-name* **mpid** *mpid-value* **service** *service-name* **Example:** `Router(config-if)#ethernet cfm mep domain carrier mpid 44 service carrier`	Sets a port to a maintenance domain and defines it as an MEP. **Note** The values for **domain** and **service** must be the same as the values configured for CFM.
Step 12	**end** **Example:** `Router(config-if-ecfm-mep)#end`	Returns the router to the privileged EXEC mode.

Configuration Example for Ethernet CFM (Port MEP)

This example shows how to configure Ethernet CFM on a port MEP:

```
Router>enable
Router#configure terminal
Router(config)#ethernet cfm ieee
Router(config)#ethernet cfm global
Router(config-ecfm)#ethernet cfm domain carrier level 2
Router(config-ecfm)#service carrier port
Router(config-ecfm-srv)#continuity-check interval 100m
Router(config-ecfm-srv)#end
Router#configure terminal
Router(config)#interface gigabitethernet 0/2
Router(config-if)#ethernet cfm mep domain carrier mpid 44 service carrier
Router(config-if-ecfm-mep)#end
```

Verifying the Ethernet CFM Configuration on a Port MEP

Use the following commands to verify Ethernet CFM configured on a port MEP:

- **show ethernet cfm domain**
- **show ethernet cfm maintenance-points local**
- **show ethernet cfm maintenance-points remote**
- **ping ethernet mpid** *mpid-value* **domain** *domain-name* **service** *service-name* **cos** *value*
- **traceroute ethernet mpid** *mpid-value* **domain** *domain-name* **service** *service-name*
- **show ethernet cfm error configuration**

Use the **show ethernet cfm domain** command to view details about CFM maintenance domains:

```
Router#show ethernet cfm domain carrier
Domain Name: carrier
Level: 2
Total Services: 1
```

```
  Services:
  Type Id   Dir CC CC-int Static-rmep Crosscheck MaxMEP Source  MA-Name
  Port none Dwn Y  100ms  Disabled    Disabled   100    Static  carrier
Router#
```

Use the **show ethernet cfm maintenance-points local** command to view the MEPs that are configured locally on a router. The following is a sample output of the **show ethernet cfm maintenance-points local** command:

```
Router#show ethernet cfm maintenance-points local
Local MEPs:
--------------------------------------------------------------------------------
MPID Domain Name                                Lvl   MacAddress     Type  CC
Ofld Domain Id                                  Dir   Port           Id
     MA Name                                          SrvcInst       Source
     EVC name
--------------------------------------------------------------------------------
44   carrier                                    2     5657.a844.04fa Port  Y
No   carrier                                    Down  Gi0/2          none
     carrier                                          N/A            Static
     N/A


Total Local MEPs: 1

Local MIPs: None
```

Use the **show ethernet cfm maintenance-points remote** command to display information about remote maintenance point domains or levels. In the following example, carrier, Provider, and customer are the maintenance point domains that are configured.

On router 1:

```
Router1#show ethernet cfm maintenance-points remote
--------------------------------------------------------------------------------
MPID  Domain Name                                MacAddress          IfSt  PtSt
 Lvl  Domain ID                                  Ingress
 RDI  MA Name                                    Type Id             SrvcInst
      EVC Name                                                       Age
      Local MEP Info
--------------------------------------------------------------------------------
43    carrier                                    5657.a86c.fa92      Up    N/A
 2    carrier                                    Gi0/2
 -    carrier                                    Port none           N/A
      N/A                                                            0s
      MPID: 44 Domain: carrier MA: carrier
33    Provider                                   5657.a86c.fa92      Up    Up
 5    Provider                                   Gi0/2.100
 -    Provider                                   Vlan 100            N/A
      N/A                                                            0s
      MPID: 34 Domain: Provider MA: Provider
3101  customer                                   5657.a86c.fa92      Up    Up
 7    customer                                   Gi0/2.1101
 -    customer1101                               S,C  100,1101       N/A
      N/A                                                            0s
      MPID: 4101 Domain: customer MA: customer1101
3102  customer                                   5657.a86c.fa92      Up    Up
 7    customer                                   Gi0/2.1102
 -    customer1102                               S,C  100,1102       N/A
      N/A                                                            0s
      MPID: 4102 Domain: customer MA: customer1102
```

```
Total Remote MEPs: 4
```

Use the **show ethernet cfm maintenance-points remote** command to view the details of a remote maintenance point domain:

On router 1:

```
Router1#show ethernet cfm maintenance-points remote domain carrier service carrier
-------------------------------------------------------------------------------
MPID  Domain Name                                MacAddress          IfSt  PtSt
 Lvl  Domain ID                                  Ingress
 RDI  MA Name                                    Type Id             SrvcInst
      EVC Name                                                       Age
      Local MEP Info
-------------------------------------------------------------------------------
43    carrier                                    5657.a86c.fa92      Up    Up
 2    carrier                                    Gi0/2
 -    carrier                                    S,C  100,1101       N/A
      N/A                                                            0s
      MPID: 44 Domain: carrier MA: carrier
Total Remote MEPs: 1
```

On router 2:

```
Router2#show ethernet cfm maintenance-points remote domain carrier service carrier
-------------------------------------------------------------------------------
MPID  Domain Name                                MacAddress          IfSt  PtSt
 Lvl  Domain ID                                  Ingress
 RDI  MA Name                                    Type Id             SrvcInst
      EVC Name                                                       Age
      Local MEP Info
-------------------------------------------------------------------------------
44    carrier                                    5657.g945.04fa      Up    Up
 2    carrier                                    Gi0/2
 -    carrier                                    S,C  100,1101       N/A
      N/A                                                            0s
      MPID: 43 Domain: carrier MA: carrier
```

Use the **ping** command to verify if Loopback Messages (LBM) and Loopback Replies (LBR) are successfully sent and received between the routers:

```
Router1#ping ethernet mpid 44 domain carrier service carrier cos 5
Type escape sequence to abort.
Sending 5 Ethernet CFM loopback messages to 5657.a86c.fa92, timeout is 5 seconds:!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
Router1#
```

Use the **traceroute** command to send the Ethernet CFM traceroute messages:

```
Router#traceroute ethernet mpid 44 domain carrier service carrier
Type escape sequence to abort. TTL 64. Linktrace Timeout is 5 seconds
Tracing the route to 5657.a86c.fa92 on Domain carrier, Level 2, service carrier
Traceroute sent via Gi0/2

B = Intermediary Bridge
! = Target Destination
* = Per hop Timeout
-------------------------------------------------------------------------------
                            MAC      Ingress        Ingr Action  Relay Action
  Hops   Host             Forwarded   Egress         Egr Action   Previous Hop
-------------------------------------------------------------------------------
```

```
! 1                   5657.a86c.fa92 Gi0/2          IngOk        RlyHit:MEP
                      Not Forwarded                               5657.g945.04fa
Router#
```

Configuring Ethernet CFM (Single-Tagged Packets)

Complete these steps to configure and enable Ethernet CFM for single-tagged packets:

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **ethernet cfm ieee**

Step 4 **ethernet cfm global**

Step 5 **ethernet cfm domain** *domain-name* **level** *level-id*

Step 6 **service** *service-name* **vlan** *vlan-id* **direction down**

Step 7 **continuity-check**

Step 8 **interface gigabitethernet** *slot/port*

Step 9 **ethernet cfm mep domain** *domain-name* **mpid** *value* **service** *service-name*

Step 10 **interface gigabitethernet** *slot/port.subinterface*

Step 11 **encapsulation dot1q** *vlan-id*

Step 12 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router>enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router#configure terminal`	Enters the global configuration mode.
Step 3	**ethernet cfm ieee** **Example:** `Router(config)#ethernet cfm ieee`	Enables the IEEE version of CFM.
Step 4	**ethernet cfm global** **Example:** `Router(config)#ethernet cfm global`	Enables CFM processing globally on the router.

	Command	Purpose
Step 5	**ethernet cfm domain** *domain-name* **level** *value* **Example:** `Router(config)#ethernet cfm domain customer level 7`	Defines a CFM maintenance domain at a specified level, and enters the Ethernet CFM configuration mode. **level** can be any value from 0 to 7.
Step 6	**service** *service-name* **vlan** *vlan-id* **direction down** **Example:** `Router(config-ecfm)#service customer1101 vlan 100 direction down`	Enters the CFM service configuration mode. **vlan**—Specifies the VLAN.
Step 7	**continuity-check** **Example:** `Router(config-ecfm-srv)#continuity-check`	Enables sending continuity check messages.
Step 8	**interface gigabitethernet** *slot/port* **Example:** `Router(config-ecfm-srv)#interface gigabitethernet 0/2`	Specifies an interface and enters the interface configuration mode.
Step 9	**ethernet cfm mep domain** *domain-name* **mpid** *mpid-value* **service** *service-name* **Example:** `Router(config-if)#ethernet cfm mep domain customer mpid 100 service customer1101`	Sets a port to a maintenance domain and defines it as an MEP. **Note** The values for **domain** and **service** must be the same as the values that were configured for CFM.
Step 10	**interface gigabitethernet** *slot/port.subinterface* **Example:** `Router(config-if-ecfm-mep)#interface gigabitethernet 0/2.1`	Specifies a subinterface and enters the subinterface configuration mode.
Step 11	**encapsulation dot1q** *vlan-id* **Example:** `Router(config-subif)#encapsulation dot1q 100`	Defines the encapsulation format as IEEE 802.1Q (dot1q), and specifies the VLAN identifier.
Step 12	**end** **Example:** `Router(config-subif)#end`	Returns the router to the privileged EXEC mode.

Configuration Example for Ethernet CFM (Single-Tagged Packets)

This example shows how to configure Ethernet CFM for single-tagged packets:

```
Router>enable
Router#configure terminal
Router(config)#ethernet cfm ieee
Router(config)#ethernet cfm global
Router(config)#ethernet cfm domain customer level 7
Router(config-ecfm)#service customer1101 vlan 100 direction down
Router(config-ecfm-srv)#continuity-check
Router(config)#interface gigabitethernet 0/2
Router(config-if)#ethernet cfm mep domain customer mpid 100 service customer1101
Router(config-if-ecfm-mep)#interface gigabitethernet 0/2.1
Router(config-subif)#encapsulation dot1q 100
Router(config-subif)#end
```

Verifying the Ethernet CFM Configuration for Single-Tagged Packets

Use the following commands to verify Ethernet CFM configured for single-tagged packets:

- **show ethernet cfm domain**
- **show ethernet cfm maintenance-points local**
- **show ethernet cfm maintenance-points remote**
- **show ethernet cfm error configuration**

Use the **show ethernet cfm domain** command to display the maintenance point domains configured in the network. In the following example, customer, enterprise, and carrier maintenance point domains are configured:

```
Router#show ethernet cfm domain
Domain Name: customer
Level: 7
Total Services: 1
  Services:
  Type Id   Dir CC CC-int Static-rmep Crosscheck MaxMEP Source  MA-Name
  Vlan 100  Dwn Y  10s    Disabled    Disabled   100    Static  customer1101

Domain Name: enterprise
Level: 6
Total Services: 1
  Services:
  Type Id   Dir CC CC-int Static-rmep Crosscheck MaxMEP Source  MA-Name
  Vlan 110  Dwn Y  10s    Disabled    Disabled   100    Static  custservice

Domain Name: carrier
Level: 2
Total Services: 1
  Services:
  Type Id   Dir CC CC-int Static-rmep Crosscheck MaxMEP Source  MA-Name
  Vlan 200  Dwn Y  10s    Disabled    Disabled   100    Static  carrier
Router#
```

Use the **show ethernet cfm maintenance-points local** command to view the local MEPs. The following is a sample output of the **show ethernet cfm maintenance-points local** command:

```
Router#show ethernet cfm maintenance-points local
-------------------------------------------------------------------------------
MPID Domain Name                                Lvl   MacAddress     Type  CC
Ofld Domain Id                                  Dir   Port           Id
     MA Name                                          SrvcInst       Source
     EVC name
-------------------------------------------------------------------------------
100  customer                                   7     70ca.9b4d.a400 Vlan  Y
```

```
No   customer                                  Down  Gi0/2          100
     customer1101                                  N/A            Static
     N/A
400  enterprise                                6     70ca.9b4d.a400 Vlan  I
No   enterprise                                Down  Gi0/1          110
     custservice                                   N/A            Static
     N/A
44   carrier                                   2     70ca.9b4d.a400 Vlan  N
No   carrier                                   Down  Gi0/2          200
     carrier                                       N/A            Static
     N/A

Total Local MEPs: 3

Local MIPs: None
Router#
```

Use the **show ethernet cfm maintenance-points remote** command to display information about remote maintenance point domains or levels.

The following example displays the continuity check messages exchanged between remote MEPs:

On router 1:

```
Router1#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------------------
MPID Domain Name             MacAddress           IfSt               PtSt
 Lvl Domain                  Ingress
 RDI MA                      Type Id              SrvcInst
     EVC Name                                     Age
     Local MEP Info
-------------------------------------------------------------------------------------------
110  customer                70ca.9b4d.a400       Up                  Up
 7   customer                Gi0/2
 -   customer1101            Vlan 100             N/A
     N/A                                          12s
     MPID: 100 Domain: customer MA: customer1101

410  enterprise              70ca.9b4d.a400       Up                  Up
 6   enterprise              Gi0/1
 -   custservice             Vlan 110             N/A
     N/A                                          12s
     MPID: 400 Domain: enterprise MA: custservice

43   carrier                 70ca.9b4d.a400       Up                  Up
 2   carrier                 Gi0/2
 -   carrier                 Vlan 200             N/A
     N/A                                          12s
     MPID: 44  Domain: carrier MA: carrier

Total Remote MEPs: 3
Router1#
```

On router 2:

```
Router2#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------------------
MPID Domain Name             MacAddress           IfSt               PtSt
 Lvl Domain                  Ingress
 RDI MA                      Type Id              SrvcInst
     EVC Name                                     Age
     Local MEP Info
-------------------------------------------------------------------------------------------
```

```
100  customer                0026.99f7.0b41       Up                   Up
 7   customer                Gi0/2
 -   customer1101            Vlan 100             N/A
     N/A                                          2s
     MPID: 110 Domain: customer MA: customer1101

400  enterprise              0026.99f7.0b41       Up                   Up
 6   enterprise              Gi0/1
 -   custservice             Vlan 110             N/A
     N/A                                          2s
     MPID: 410 Domain: enterprise MA: custservice

44   carrier                 0026.99f7.0b41       Up                   Up
 2   carrier                 Gi0/2
 -   carrier                 Vlan 200             N/A
     N/A                                          2s
     MPID: 43  Domain: carrier MA: carrier

Total Remote MEPs: 3
Router2#
```

Use the **show ethernet cfm error configuration** command to view Ethernet CFM configuration errors (if any). The following is a sample output of the **show ethernet cfm error configuration** command:

```
Router#show ethernet cfm error configuration
--------------------------------------------------------------------------------
CFM Interface      Type  Id       Level    Error type
--------------------------------------------------------------------------------
Gi0/2              S,C   100      5        CFMLeak
```

Configuring Ethernet CFM (Double-Tagged Packets)

Complete these steps to configure and enable Ethernet CFM for double-tagged packets:

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **ethernet cfm ieee**

Step 4 **ethernet cfm global**

Step 5 **ethernet cfm domain** *domain-name* **level** *value*

Step 6 **service** *service-name* **vlan** *vlan-id* **inner-vlan** *inner-vlan-id* **direction down**

Step 7 **continuity-check**

Step 8 **interface gigabitethernet** *slot/port*

Step 9 **ethernet cfm mep domain** *domain-name* **mpid** *mpid-value* **service** *service-name*

Step 10 **interface gigabitethernet** *slot/port.subinterface*

Step 11 **encapsulation dot1q** *vlan-id* **second-dot1q** *inner vlan-id*

Step 12 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router>enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router#configure terminal`	Enters the global configuration mode.
Step 3	**ethernet cfm ieee** **Example:** `Router(config)#ethernet cfm ieee`	Enables the IEEE version of CFM.
Step 4	**ethernet cfm global** **Example:** `Router(config)#ethernet cfm global`	Enables CFM processing globally on the router.
Step 5	**ethernet cfm domain** *domain-name* **level** *0 to 7* **Example:** `Router(config-ecfm)#ethernet cfm domain customer level 7`	Defines a CFM maintenance domain at a specified level, and enters Ethernet CFM configuration mode. **level** can be any value from 0 to 7.
Step 6	**service** *service-name* **vlan** *vlan-id* **inner-vlan** *inner vlan-id* **direction down** **Example:** `Router(config-ecfm)#service customer1101 vlan 100 inner-vlan 30 direction down`	Enters the CFM service configuration mode. The following are the parameters: • **vlan**—Specifies the VLAN. • **inner-vlan**—The **inner-vlan** keyword and the *inner vlan-id* argument specify the VLAN tag for double-tagged packets.
Step 7	**continuity-check** **Example:** `Router(config-ecfm-srv)#continuity-check`	Enables sending continuity check messages.
Step 8	**interface gigabitethernet** *slot/port* **Example:** `Router(config-ecfm-srv)#interface gigabitethernet 0/2`	Specifies an interface and enters the interface configuration mode.

	Command	Purpose
Step 9	**ethernet cfm mep domain** *domain-name* **mpid** *mpid-value* **service** *service-name* **Example:** `Router(config-if)#ethernet cfm mep domain customer mpid 100 service customer1101`	Sets a port to a maintenance domain and defines it as an MEP. **Note** The values for **domain** and **service** must be the same as the values configured for CFM. **MPID**—Specifies the maintenance endpoint identifier.
Step 10	**interface gigabitethernet** *slot/port.subinterface* **Example:** `Router(config-if-ecfm-mep)#interface gigabitethernet 0/2.1101`	Specifies a subinterface and enters the subinterface configuration mode.
Step 11	**encapsulation dot1q** *vlan-id* **second-dot1q** *inner vlan-id* **Example:** `Router(config-subif)#encapsulation dot1q 100 second-dot1q 30`	Defines the encapsulation format as IEEE 802.1Q (dot1q), and specifies the VLAN identifier. Use the **second-dot1q** keyword and the *inner vlan-id* argument to specify the VLAN tag.
Step 12	**end** **Example:** `Router(config-subif)#end`	Returns the router to the privileged EXEC mode.

Configuration Example for Ethernet CFM (Double-Tagged Packets)

This example shows how to configure Ethernet CFM for double-tagged packets:

```
Router>enable
Router#configure terminal
Router(config)#ethernet cfm ieee
Router(config)#ethernet cfm global
Router(config-ecfm)#ethernet cfm domain customer level 7
Router(config-ecfm)#service customer1101 vlan 100 inner-vlan 30 direction down
Router(config-ecfm-srv)#continuity-check
Router(config-ecfm-srv)#interface gigabitethernet 0/2
Router(config-if)#ethernet cfm mep domain customer mpid 100 service customer1101
Router(config-if-ecfm-mep)#interface gigabitethernet 0/2.1101
Router(config-subif)#encapsulation dot1q 100 second-dot1q 30
Router(config-subif)#end
```

Verifiying the Ethernet CFM Configuration for Double-Tagged Packets

Use the following commands to verify Ethernet CFM configured for double-tagged packets:

- **show ethernet cfm maintenance-points local**
- **show ethernet cfm maintenance-points remote**
- **ping ethernet mpid** *mpid-value* **domain** *domain-name* **service** *service-name* **cos** *value*
- **traceroute ethernet mpid** *mpid-value* **domain** *domain-name* **service** *service-name*
- **show ethernet cfm error configuration**

Use the **show ethernet cfm maintenance-points local** command to view the local MEPs. The following is a sample output of the **show ethernet cfm maintenance-points local** command:

```
Router#show ethernet cfm maintenance-points local
-------------------------------------------------------------------------------
MPID Domain Name          MacAddress                 IfSt                    PtSt
 Lvl Domain ID          Ingress
 RDI MA Name              Type Id                    SrvcInst
     EVC Name                              Age
     Local MEP Info
-------------------------------------------------------------------------------
100  customer             8843.e154.6f01             Up                      Up
 7   customer             Gi0/2.1101
 -   customer1101         S, C 100, 30               N/A
     N/A                                   58s
     MPID: 100 Domain: customer MA: customer1101
Router#
```

Use the **show ethernet cfm maintenance-points remote** command to display the remote maintenance point domains. In the following example, customer, carrier, and enterprise are the maintenance point domains that are configured:

On router 1:

```
Router1#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------
MPID Domain Name          MacAddress                 IfSt                    PtSt
 Lvl Domain ID          Ingress
 RDI MA Name              Type Id                    SrvcInst
     EVC Name                                       Age
     Local MEP Info
-------------------------------------------------------------------------------
110  customer             8843.e154.6f01             Up                      Up
 7   customer             Gi0/2.1101
 -   customer1101         S, C 100, 30               N/A
     N/A                                            58s
     MPID: 100 Domain: customer MA: customer1101

43   carrier              8843.e154.6f01             Up                      Up
 2   carrier              Gi0/2.2
 -   carrier              S, C 50, 20                N/A
     N/A                                            58s
     MPID: 44 Domain: carrier MA: carrier

410  enterprise           8843.e154.6f01             Up                      Up
 6   enterprise           Gi0/1.1
 -   custservice          S, C 200, 70               N/A
     N/A                                            58s
     MPID: 400 Domain: enterprise MA: custservice

Router1#
```

On router 2:

```
Router2#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------
MPID Domain Name          MacAddress                 IfSt                    PtSt
 Lvl Domain ID          Ingress
 RDI MA Name              Type Id                    SrvcInst
     EVC Name                                       Age
     Local MEP Info
-------------------------------------------------------------------------------
```

```
100  customer             0026.99f7.0b41             Up                    Up
 7   customer             Gi0/2.1101
 -   customer1101         S, C 100, 30               N/A
     N/A                                             40s
     MPID: 110 Domain: customer MA: customer1101

44   carrier              0026.99f7.0b41             Up                    Up
 2   carrier              Gi0/2.2
 -   carrier              S, C 50, 20                N/A
     N/A                                             40s
     MPID: 43 Domain: carrier MA: carrier

400  enterprise           0026.99f7.0b41             Up                    Up
 6   enterprise           Gi0/1.1
 -   custservice          S, C 200, 70               N/A
     N/A                                             40s
     MPID: 410 Domain: enterprise MA: custservice

Router2#
```

Use the **ping** command to verify if Ethernet CFM loopback messages are successfully sent and received between the routers:

```
Router#ping ethernet mpid 100 domain customer service customer1101  cos 5
Type escape sequence to abort.
Sending 5 Ethernet CFM loopback messages to 8843.e154.6f01, timeout is 5 seconds:!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
Router#
```

Use the **traceroute** command to send the Ethernet CFM traceroute messages:

```
Router#traceroute ethernet mpid 100 domain customer service customer1101
Type escape sequence to abort. TTL 64. Linktrace Timeout is 5 seconds
Tracing the route to 8843.e154.6f01 on Domain customer, Level 7, service customer1101,
vlan 100 inner-vlan 30
Traceroute sent via Gi0/2.1101

B = Intermediary Bridge
! = Target Destination
* = Per hop Timeout
-------------------------------------------------------------------------------
                            MAC      Ingress        Ingr Action  Relay Action
  Hops   Host             Forwarded  Egress         Egr Action   Previous Hop
-------------------------------------------------------------------------------
! 1                   8843.e154.6f01 Gi0/2.1101 IngOk        RlyHit:MEP
                     Not Forwarded                              5657.a86c.fa92
```

Use the **show ethernet cfm error configuration** command to view Ethernet CFM configuration errors (if any). The following is a sample output of the **show ethernet cfm error configuration** command:

```
Router#show ethernet cfm error configuration
-------------------------------------------------------------------------------
CFM Interface      Type  Id         Level    Error type
-------------------------------------------------------------------------------
Gi0/2              S,C   100,30     5        CFMLeak
Gi0/2              S,C   100,30     1        CFMLeak
```

Troubleshooting Ethernet CFM Configuration

Table 3 lists the debug commands to troubleshoot issues pertaining to the Ethernet CFM configuration.

The Cisco IOS Master Command List at

http://www.cisco.com/en/US/docs/ios/mcl/allreleasemcl/all_book.html provides more information about these commands.

Caution Because debugging output is assigned high priority in the CPU process, it can diminish the performance of the router or even render it unusable. For this reason, use debug commands only to troubleshoot specific problems or during troubleshooting sessions with Cisco technical support staff.

Note Before you run any of the debug commands listed in the following table, ensure that you run the **logging buffered debugging** command, and then turn off console debug logging using the **no logging console** command.

Table 3 debug Commands for Ethernet CFM Configuration

debug Command	Purpose
debug ethernet cfm all	Enables all Ethernet CFM debug messages.
debug ethernet cfm diagnostic	Enables low-level diagnostic debugging of Ethernet CFM general events or packet-related events.
debug ethernet cfm error	Enables debugging of Ethernet CFM errors.
debug ethernet cfm packets	Enables debugging of Ethernet CFM message packets.
debug ecfmpal all	Enables debug messages for all Ethernet CFM platform events.
debug ecfmpal api	Displays debug messages for all Ethernet CFM platform API events.
debug ecfmpal common	Displays debug messages for all Ethernet CFM platform common events.
debug ecfmpal ecfmpal	Enables debugging of all Ethernet CFM platform events.
debug ecfmpal epl	Enables debugging of all Ethernet CFM platform endpoint list (EPL) events.
debug ecfmpal isr	Enables debugging of all Ethernet CFM platform interrupt service request (ISR) events.

Support for Y.1731 Performance Monitoring on a Routed Port (L3 Subinterface)

Y.1731 Performance Monitoring (PM) provides a standard Ethernet PM function that includes measurement of Ethernet frame delay, frame delay variation, frame loss, and frame throughput measurements specified by the ITU-T Y-1731 standard and interpreted by the Metro Ethernet Forum (MEF) standards group.

Note This feature is supported only if you have purchased the DATA technology package functionality (*datak9*) licensing package. For more information about managing software activation licenses on the Cisco ISR and Cisco ISR G2 platforms, see http://www.cisco.com/en/US/docs/routers/access/sw_activation/SA_on_ISR.html.

Frame Delay

Ethernet frame delay measurement is used to measure frame delay and frame delay variations. Ethernet frame delay is measured using the Delay Measurement Message (DMM) method.

Restrictions for Configuring Two-Way Delay Measurement

Follow the guidelines and restrictions listed here when you configure two-way delay measurement:

- Y.1731 PM measurement works only for a point-to-point network topology.
- The granularity of the clock for delay measurement is in seconds and nanoseconds.
- CFM Y.1731 packets work with a maximum of two VLAN tags. The expected behavior is not observed with more VLAN tags. Also, CFM Y.1731 packets do not work with untagged cases.

Configuring Two-Way Delay Measurement

The following steps show how to configure two-way delay measurement. Both single and double tagging methods are included in the steps listed below.

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **ip sla** *operation number*

Step 4 **ethernet y1731 delay** *DMM* **domain** *value* **vlan** *vlan-id* **mpid** *value* **cos** *value* **source mpid** *value*

or

ethernet y1731 delay *DMM* **domain** *value* **vlan** *vlan-id* **inner-vlan** *inner vlan-id* **mpid** *value* **cos** *value* **source mpid** *value*

Step 5 **aggregate interval** *seconds*

Step 6 **exit**

Step 7 **ip sla schedule** *operation number* **start-time** {*start time* | *now*}

Step 8 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters the global configuration mode.
Step 3	**ip sla** *operation number* **Example:** `Router(config)# ip sla 1101`	Enables the IP SLA configuration. *operation-number*—The IP SLA operation you want to configure.

Step 4	**ethernet y1731 delay** *DMM* **domain** *value* **vlan** *vlan-id* **mpid** *value* **cos** *value* **source mpid** *value*
	
	or
	
	ethernet y1731 delay *DMM* **domain** *value* **vlan** *vlan-id* **inner-vlan** *inner vlan-id* **mpid** *value* **cos** *value* **source mpid** *value*
	
	Example:
	`Router(config-ip-sla)# ethernet y1731 delay DMM domain customer vlan 100 mpid 3101 cos 1 source mpid 4101`
	
	or
	
	`Router(config-ip-sla)# ethernet y1731 delay DMM domain customer vlan 100 inner-vlan 1101 mpid 3101 cos 1 source mpid 4101`
		Configures a two-way delay measurement.
		Note Both single tagging and double tagging are supported.
		The following are the parameters:
		• **delay**—Specifies the delay distribution parameter.
		Note DMM is the only supported delay distribution parameter.
		• **vlan**—Specifies the VLAN.
		• **inner-vlan**—The **inner-vlan** keyword and the *inner vlan-id* argument specify the VLAN tag for double-tagged packets.
		• **cos**—Specifies the CoS. The value can be any number between 0 and 7.
		Note For double-tagged packets, the **cos** value corresponds to the value specified for the outer tag.
		• **mpid**—Specifies the destination MPID.
		• **source**—Specifies the source MPID.

Step 5	**aggregate interval** *seconds* **Example:** `Router(config-sla-y1731-delay)# aggregate interval 30`	Configures the Y.1731 aggregation parameter, where **aggregate interval** refers to the interval at which the packets are sent. *seconds*—Specifies the length of time, in seconds.

	Command	Purpose
Step 6	**exit** **Example:** `Router(config-sla-y1731-delay)# exit`	Exits the router configuration mode.
Step 7	**ip sla schedule** *operation number* **life** {*value* | *forever*} **start-time** *value* **Example:** `Router(config)#ip sla schedule 1101 life forever start-time now`	Schedules the two-way delay measurement. • **life**—Specifies a period of time (in seconds) to execute. The value can also be set as *forever.* • **start-time**—Specifies the time at which to start the entry. The options available are *after, hh:mm, hh:mm:ss, now,* and *pending*.
Step 8	**end** **Example:** `Router(config)#end`	Exits the router configuration mode and returns to the privileged EXEC mode.

Configuration Examples for Two-Way Delay Measurement

This example shows how to configure two-way delay measurement using single tagging:

```
router>enable
router#configure terminal
router(config)#ip sla 1101
router(config-ip-sla)#ethernet y1731 delay DMM domain customer vlan 100 mpid 3101 cos 1
router(config-sla-y1731-delay)#aggregate interval 30
router(config-sla-y1731-delay)#exit
router(config)#ip sla schedule 1102 life forever start-time now
router(config)#end
```

This example shows how to configure two-way delay measurement using double tagging:

```
router>enable
router#configure terminal
router(config)#ip sla 1101
router(config-ip-sla)#ethernet y1731 delay DMM domain customer vlan 100 inner-vlan 1101
mpid 3101 cos 1 source mpid 4101
router(config-sla-y1731-delay)#aggregate interval 30
router(config-sla-y1731-delay)#exit
router(config)#ip sla schedule 1101 life forever start-time now
router(config)#end
```

Verifying Two-Way Delay Measurement Configuration

Use the following commands to verify the performance-monitoring sessions:

- **show run | sec ip sla**
- **show ip sla summary**
- **show ip sla statistics** *entry-number*
- **show ip sla configuration** *entry-number*
- **show ethernet cfm pm session summary**
- **show ethernet cfm pm session detail** *session-id*

- **show ethernet cfm pm session db** *session-id*

The following are the sample outputs of the commands listed above:

```
Router#show run | sec ip sla
ip sla auto discovery
ip sla 1101
 ethernet y1731 delay DMM domain customer vlan 100 inner-vlan 1101 mpid 3101 cos
 1 source mpid 4101
ip sla schedule 1101 life forever start-time now

Router#show ip sla summary
IPSLAs Latest Operation Summary
Codes: * active, ^ inactive, ~ pending

ID           Type        Destination       Stats       Return      Last
                                           (ms)        Code        Run
---------------------------------------------------------------------
*1101        y1731-delay Domain:customer V -           OK          27 seconds ag
                         lan:100 CVlan:110                         o
                         1 Mpid:3101

Router#show ip sla statistics
IPSLAs Latest Operation Statistics

IPSLA operation id: 1101
Delay Statistics for Y1731 Operation 1101
Type of operation: Y1731 Delay Measurement
Latest operation start time: *10:43:12.930 UTC Mon Oct 21 2013
Latest operation return code: OK
Distribution Statistics:
Interval
 Start time:  *10:43:12.930 UTC Mon Oct 21 2013
 Elapsed time: 15 seconds
 Number of measurements initiated: 7
 Number of measurements completed: 7
 Flag: OK

Router#show ip sla configuration 1101
IP SLAs Infrastructure Engine-III
Entry number: 1101
Owner:
Tag:
Operation timeout (milliseconds): 5000
Ethernet Y1731 Delay Operation
Frame Type: DMM
Domain: customer
Vlan: 100
CVlan: 1101
Target Mpid: 3101
Source Mpid: 4101
CoS: 1
   Max Delay: 5000
   Request size (Padding portion): 64
   Frame Interval: 1000
   Clock: Not In Sync
Threshold (milliseconds): 5000
Schedule:
   Operation frequency (seconds): 30  (not considered if randomly scheduled)
   Next Scheduled Start Time: Start Time already passed
   Group Scheduled : FALSE
   Randomly Scheduled : FALSE
   Life (seconds): Forever
   Entry Ageout (seconds): never
```

```
   Recurring (Starting Everyday): FALSE
   Status of entry (SNMP RowStatus): Active
Statistics Parameters
  Frame offset: 1
  Distribution Delay Two-Way:
   Number of Bins 10
   Bin Boundaries: 5000,10000,15000,20000,25000,30000,35000,40000,45000,-1
  Distribution Delay-Variation Two-Way:
   Number of Bins 10
   Bin Boundaries: 5000,10000,15000,20000,25000,30000,35000,40000,45000,-1
  Aggregation Period: 30
History
  Number of intervals: 2

Router#show ethernet cfm pm session summary
Number of Configured Session : 150
Number of Active Session: 2
Number of Inactive Session: 148
Router#

Router(config)#show ethernet cfm pm session detail 0
Session ID: 0
Sla Session ID: 1101
Level: 7
Service Type: S,C
Service Id: 100,1101
Direction: Down
Source Mac: 5352.a824.04fr
Destination Mac: 5067.a87c.fa92
Session Version: 0
Session Operation: Proactive
Session Status: Active
MPID: 4101
Tx active: yes
Rx active: yes
RP monitor Tx active: yes
RP monitor Rx active: yes
Timeout timer: stopped
Last clearing of counters: *00:00:00.000 UTC Mon Jan 1 1900
DMMs:
   Transmitted: 117
DMRs:
   Rcvd: 117
1DMs:
   Transmitted: 0
   Rcvd: 0
LMMs:
   Transmitted: 0
LMRs:
   Rcvd: 0
VSMs:
   Transmitted: 0
VSRs:
   Rcvd: 0
SLMs:
   Transmitted: 0
SLRs:
   Rcvd: 0
Test ID 0
Router1#

Router#show ethernet cfm pm session db 0
------------------------------------------------------------------------------
      TX Time FWD                   RX Time FWD
```

```
      TX Time BWD                    RX Time BWD              Frame Delay
      Sec:nSec                       Sec:nSec                  Sec:nSec
--------------------------------------------------------------------------------
Session ID: 0
********************************************************************************
3591340722:930326034           3591340663:866791722
3591340663:866898528           3591340722:930707484            0:274644
********************************************************************************
3591340723:927640626           3591340664:864091056
3591340664:864182604           3591340723:927976302            0:244128
********************************************************************************
3591340724:927640626           3591340665:864091056
3591340665:864167346           3591340724:927961044            0:244128
********************************************************************************
3591340725:927671142           3591340666:864121572
3591340666:864213120           3591340725:928006818            0:244128
********************************************************************************
3591340726:927655884           3591340667:864106314
3591340667:864197862           3591340726:927991560            0:244128
********************************************************************************
3591340727:927732174           3591340668:864167346
3591340668:864533538           3591340727:928327236            0:228870
********************************************************************************
3591340728:927655884           3591340669:864121572
3591340669:864197862           3591340728:928006818            0:274644
********************************************************************************
3591340729:927671142           3591340670:864121572
3591340670:864197862           3591340729:927991560            0:244128
********************************************************************************
```

Troubleshooting Two-Way Delay Measurement Configuration

Table 4 lists the debug commands to troubleshoot issues pertaining to the two-way delay measurement configuration. The Cisco IOS Master Command List at

http://www.cisco.com/en/US/docs/ios/mcl/allreleasemcl/all_book.html provides more information about these commands.

Caution Because debugging output is assigned high priority in the CPU process, it can diminish the performance of the router or even render it unusable. For this reason, use debug commands only to troubleshoot specific problems or during troubleshooting sessions with Cisco technical support staff.

Note Before you run any of the debug commands listed in the following table, ensure that you run the **logging buffered debugging** command, and then turn off console debug logging using the **no logging console** command.

Table 4 debug Commands for Two-Way Delay Measurement Configuration

debug Command	Purpose
debug epmpal all	Enables debugging of all Ethernet performance monitoring (PM) events.
debug epmpal api	Enables debugging of Ethernet PM API events.

Table 4 debug Commands for Two-Way Delay Measurement Configuration (continued)

debug Command	Purpose
debug epmpal rx	Enables debugging of Ethernet PM packet-receive events.
debug epmpal tx	Enables debugging of Ethernet PM packet-transmit events.

Configuring Ethernet Virtual Connection Bridge Domain

Ethernet virtual connection (EVC) infrastructure is a Layer 2 platform-independent bridging architecture that supports Ethernet services. This chapter provides procedures for configuring EVC Bridge Domain (BD) and the features it supports on the Cisco Integrated Services Routers (ISR) G2.

- Configuring EVCs on Cisco ISR G2 Router, page 61
- Ethernet Data Plane Loopback, page 64
- Connectivity Fault Management (CFM) over EVC BD, page 68
- Support for Y.1731 Performance Monitoring for EVC BD, page 87
- Support for Switch Virtual Interfaces (SVI) on ISR G2 Metro Ethernet BD, page 90
- EVC Quality of Service (QoS), page 92

Configuring EVCs on Cisco ISR G2 Router

Configuring an EFP and a BD on the Cisco ISR G2 Router

Configuring a service instance on a Layer 2 port creates an EFP on which you can configure EVC features.

Note

- You cannot use the same VLAN ID for encapsulating on a Layer 3 sub-interface and an EFP (service instance) on a WAN interface.
- If there is a sub-interface and service-instance both configured on a WAN interface for untagged traffic, then the traffic will always go to the main interface and the service-instance with untagged traffic will not work.

Perform this task to configure an EFP.

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **interface** *type number*

Step 4 **service instance** *id* **ethernet**

Step 5 **encapsulation** *encapsulation-type vlan-id*

Step 6 **rewrite ingress tag translate 1-to-1 dot1q** *vlan-id* **symmetric**

Step 7 **bridge-domain** *bridge-id*

Step 8 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface gigabitethernet 0/1`	Enters interface configuration mode. • The example shows how to configure Gigabit Ethernet interface 0/1 and enter interface configuration mode.
Step 4	**service instance** *id* **ethernet** **Example:** `Router(config-if)# service instance 1 ethernet`	Configures an Ethernet service instance on an interface and enters Ethernet service configuration mode. • The example shows how to configure Ethernet service instance 1.
Step 5	**encapsulation** *encapsulation-type vlan-id* **Example:** `Router(config-if-srv)# encapsulation dot1q 1`	Defines the encapsulation type. • The example shows how to define dot1q as the encapsulation type.
Step 6	**rewrite ingress tag translate 1-to-1 dot1q** *vlan-id* **symmetric** **Example:** `Router(config-if-srv)# rewrite ingress tag translate 1-to-1 dot1q 1 symmetric`	(Optional) Specifies the encapsulation adjustment to be performed on a frame ingressing a service instance. • The example shows how to specify translating a single tag defined by the **encapsulation** command to a single tag defined in the **rewrite ingress tag** command with reciprocal adjustment to be done in the egress direction.

	Command	Purpose
Step 7	**bridge-domain** *bridge-id* **Example:** `Router(config-if-srv)# bridge-domain 1`	Configures the bridge domain. • The example shows how to configure bridge domain 1.
Step 8	**end** **Example:** `router(config-if-srv)# end`	Returns to privileged EXEC mode.

Configuration Examples for EVCs on the Cisco ISR G2 Router

When a WAN interface is configured with both an EFP and a subinterface, and the dot1q encapsulation with the same VLAN ID is used, the traffic on the subinterface gets a higher priority than the traffic on an EFP.

Note the following configuration order before you configure EVC:

Order 1: If you configure the subinterface with the same VLAN ID first, then the configuration of EFP using the same VLAN ID is blocked as shown below:

```
router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
router(config)#int gi0/0
irouter(config-if)# service instance 2 ethernet evc1
router(config-if-srv)# encapsulation dot1q 102
Invalid configuration on ServInst 2(Gi0/0). The VLAN ID (102) has already been configured
on interface GigabitEthernet0/0.102
```

Order 2: If you configure EFP first using the same VLAN ID, then you can still configure the subinterface using the same VLAN ID. However, traffic will flow on the subinterface with higher priority and not on the EFP.

Configuring an EFP and a subinterface using the same VLAN ID for dot1q encapsulation is allowed and configurable as show in order 2. However, the use of an EFP and subinterface is mutually exclusive. There will not be any traffic through the EFP. Traffic only goes through the subinterface because untagged packets have high priority than tagged packets.

Example Configuring EFPs on a Gigabit Ethernet Interface

```
interface GigabitEthernet0/1
 no ip address
 negotiation auto
 service instance 1 ethernet
 encapsulation dot1q 201
 rewrite ingress tag translate 1-to-1 dot1q 300 symmetric
 bridge-domain 1
 !
 service instance 2 ethernet
 encapsulation default
 bridge-domain 1
 !
 service instance 3 ethernet
 encapsulation priority-tagged
 bridge-domain 2
 !
```

Ethernet Data Plane Loopback

The Ethernet Data Plane Loopback feature allows you to test services and throughput of an Ethernet port or a device using a test generator. You can verify the maximum rate of frame transmission with no frame loss. This feature allows bidirectional throughput measurement, and on-demand or out-of-service (intrusive) operation during service turn-ups. This feature is used for testing during service turn-ups and troubleshooting of services after a turn-up.

If you need to test a service while it is live, you do this without disrupting any of the live data traffic. To achieve this, you use test traffic that differs from live data traffic. For example, the traffic from a test generator contain the source MAC address of the test generator, or test traffic is assigned a particular Class of Service (Cos). Irrespective of the method used, the device looping back the traffic must be able to filter out the test traffic and leave the data traffic untouched.

Note Configuring Ethernet Data Plane Loopback on a device does not indicate the start of an actual session.

Features Supported for Ethernet Data Plane Loopback

- Locally-enabled Ethernet Data Plane Loopback on all Ethernet interface types, such as physical and bundle interfaces and sub-interfaces and Pseudowire Head End (PWHE) interfaces.
- In the case of Layer 2 and Layer 3 interfaces, only external loopback is supported. External loopback is the type of loopback where all traffic received on the ingress interface is blindly sent out of the egress interface.
- When a Bundle interface is placed into loopback, traffic on all bundle link members are looped back.
- MAC address must always be swapped on looped-back traffic.
- Supports dropping of packets received in the non-loopback direction.
- Allows the application of multiple filters to loopback only a subset of traffic received by an interface and only drop the corresponding reverse-direction traffic.
- Provides an option to specify a time period after which the loopback is automatically terminated.

Restrictions of Ethernet Data Plane Loopback

- EVC xconnect is not supported.
- Only single VLAN is supported as the filtering options, but the vlan-list/vlan range is not supported.
- Maximum of 10 active sessions is only supported.

Configuring Ethernet Data Plane Loopback

Perform this task to configure Ethernet Data Plane Loopback.

Note Configuring or permitting Ethernet Data Plane Loopback is not the same as starting an actual loopback session.

SUMMARY STEPS

Step 1 **configure**

Step 2 **interface [GigabitEthernet |]** *interface-path-id*

Step 3 **ethernet loopback permit {external | internal}**

Step 4 **end**

or

commit

DETAILED STEPS

	Command	Purpose
Step 1	**configure** **Example:** `Router# configure`	Enters global configuration mode.
Step 2	**interface [GigabitEthernet |]** *interface-path-id* **Example:** `router(config)# interface 0/1`	Enters interface configuration mode and specifies the Ethernet interface name and notation *rack/slot/module/port*. **Note** The example indicates an 8-port 10-Gigabit Ethernet interface in modular services card slot 1.

	Command	Purpose
Step 3	**ethernet loopback permit {external | internal}** **Example:** `Router(config-if-srv)# ethernet loopback permit external`	Configures ethernet loopback externally or internally on an interface. External loopback allows loopback of traffic from wire. Internal loopback allows loopback of traffic from the bridge domain.
Step 4	**end** or **commit** **Example:** `router(config-if-srv)# commit`	Saves configuration changes. • When you issue the end command, the system prompts you to commit changes: Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]: – Entering yes saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering no exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering cancel leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the commit command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuration Examples for Ethernet Data Plane Loopback

This example shows how to configure Ethernet Data Plane Loopback:

```
Router# configure
Router(config)# interface GigabitEthernet 0/1
Router((config-if-srv)# ethernet loopback permit external
```

This example shows how to start an Ethernet Data Plane Loopback:

```
Router# ethernet loopback start local interface gigabitEthernet 0/1
external
[source mac-address <addr>]
[destination mac-address <addr>]
[ether-type <etype>]
[{dot1q <vlan-ids> [second-dot1q <vlan-ids>] |
dot1ad <vlan-ids> [dot1q <vlan-ids>]}]
[cos <cos>]
[llc-oui <oui>]
[timeout {<length> | none}]
```

This example shows how to stop an Data Plane Loopback:

```
Router# ethernet loopback stop local interface <name> id <id>
```

This example shows how to extend an Ethernet Data Plane Loopback:

```
router# ethernet loopback extend local interface <name> id <id> length
```

```
<length>
```

Verifying the Ethernet Data Plane Loopback Configuration

Use the **show ethernet loopback permitted** command to display all the permitted interfaces which run Ethernet Data Plane Loopback sessions:

```
router# show ethernet loopback permitted

Interface Direction
--------------------------------------------------------------------------------
GigabitEthernet0/0/0/0 External
GigabitEthernet0/0/0/1.100 Internal
GigabitEthernet 0/1.200 External, Internal
```

Use the **show ethernet loopback active** command to view active sessions:

```
Router# show ethernet loopback active interface GigabitEthernet 0/1.200

Local: GigabitEthernet0/1.200, ID 1
--------------------------------------------------------------------------------
Direction: Internal
Time out: 2 hours
Time left: 00:01:17
Status: Active
Filters:
Dot1ad: 100-200
Dot1q: Any
Source MAC Address: aaaa.bbbb.cccc
Destination MAC Address: Any
Ethertype: 0x8902
Class of Service: Any
LLC-OUI: Any
Local: GigabitEthernet0/1.200, ID 2
--------------------------------------------------------------------------------
Direction: External
Time out: 10 minutes
Time left: 00:00:00
Status: Stopping
Filters:
Dot1q: 500
Second-dot1q: 200
Source MAC Address: Any
Destination MAC Address: Any
Ethertype: Any
Class of Service: 4
LLC-OUI: Any
```

For each loopback session listed, this information is displayed:

- Header containing the Interface name and session ID, which uniquely identify the local loopback session,
- Direction which specifies the direction of the loopback,
- Time out – the time out period specified when the loopback was started,
- Time left – the amount of time left until the loopback session is automatically stopped,
- Status – the status of the loopback session,
- Filters – details of the filters specified when the loopback session was started. Similar to the start CLI, only the filters supported by the platform are displayed.

Connectivity Fault Management (CFM) over EVC BD

IEEE CFM is an end-to-end per-service Ethernet-layer Operations, Administration, and Maintenance (OAM) protocol. CFM includes proactive connectivity monitoring, fault verification, and fault isolation for large Ethernet metropolitan-area networks (MANs) and WANs.

CFM over EVC BD (Up mep) and CFM over EVC BD (Down mep) features are supported on CFM over EVC BD.

CFM over Xconnect (Up mep) and CFM over Xconnect (Down mep) features are not supported on CFM over EVC BD.

The benefits of Ethernet CFM are:

- End-to-end service-level OAM technology
- Reduced operating expense for service provider Ethernet networks
- Competitive advantage for service providers

Note This feature is supported only if you have purchased the *appxk9* licensing package. CFM over EVC BD is available only on the Cisco 890 series ISR and ISRG2 platforms. For more information about managing software activation licenses on the Cisco ISR and Cisco ISR G2 platforms, see http://www.cisco.com/en/US/docs/routers/access/sw_activation/SA_on_ISR.html.

Restrictions for Configuring Ethernet CFM

- A specific domain must be configured. If it is not, an error message is displayed.
- Multiple domains (different domain names) having the same maintenance level can be configured. However, associating a single domain name with multiple maintenance levels is not permitted.

Configuring Ethernet CFM

- Provisioning the Network (CE-A), page 68
- Provisioning the Network (CE-B), page 70
- Provisioning Service (CE-A), page 73
- Provisioning Service (CE-B), page 76
- Configuring and Enabling the Cross-Check Function (CE-A), page 78
- Configuring and Enabling the Cross-Check Function (CE-B), page 80
- Configuration Examples for Configuring Ethernet CFM for the Cisco ISR G2 Routers, page 81

Provisioning the Network (CE-A)

Complete these steps to configure provisioning the network (CE-A):

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **ethernet cfm domain** *domain-name* **level** *level-id*

Step 4 **mep archive-hold-time** *minutes*

Step 5 **exit**

Step 6 **ethernet cfm global**

Step 7 **ethernet cfm ieee**

Step 8 **ethernet cfm traceroute cache**

Step 9 **ethernet cfm traceroute cache size** *entries*

Step 10 **ethernet cfm traceroute cache hold-time** *minutes*

Step 11 **snmp-server enable traps ethernet cfm cc [mep-up] [mep-down] [config] [loop] [cross-connect]**

Step 12 **snmp-server enable traps ethernet cfm crosscheck [mep-unknown] [mep-missing] [service-up]**

Step 13 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters the global configuration mode.
Step 3	**ethernet cfm domain** *domain-name* **level** *level-id* **Example:** `Router(config)# ethernet cfm domain Customer level 7`	Defines a CFM maintenance domain at a particular maintenance level and enters Ethernet CFM configuration mode.
Step 4	**mep archive-hold-time** *minutes* **Example:** `Router(config-ecfm)# mep archive-hold-time 60`	Sets the amount of time that data from a missing MEP is kept in the continuity check database or that entries are held in the error database before they are purged.
Step 5	**exit** **Example:** `Router(config-ecfm)# exit`	Returns the device to global configuration mode.
Step 6	**ethernet cfm global** **Example:** `Router(config)# ethernet cfm global`	Enables CFM processing globally on the device.

	Command	Purpose
Step 7	**ethernet cfm ieee** **Example:** `Router(config)# ethernet cfm ieee`	Enables the CFM IEEE version of CFM. • This command is automatically issued when the ethernet cfm global command is issued.
Step 8	**ethernet cfm traceroute cache** **Example:** `Router(config)# ethernet cfm traceroute cache`	Enables caching of CFM data learned through traceroute messages.
Step 9	**ethernet cfm traceroute cache size** *entries* **Example:** `Router(config)# ethernet cfm traceroute cache size 200`	Sets the maximum size for the CFM traceroute cache table.
Step 10	**ethernet cfm traceroute cache hold-time** *minutes* **Example:** `Router(config)# ethernet cfm traceroute cache hold-time 60`	Sets the amount of time that CFM traceroute cache entries are retained.
Step 11	**snmp-server enable traps ethernet cfm cc [mep-up] [mep-down] [config] [loop] [cross-connect]** **Example:** `Router(config)# snmp-server enable traps ethernet cfm cc mep-up mep-down config loop cross-connect`	Enables SNMP trap generation for Ethernet CFM continuity check events.
Step 12	**snmp-server enable traps ethernet cfm crosscheck [mep-unknown] [mep-missing] [service-up]** **Example:** `Router(config)# snmp-server enable traps ethernet cfm crosscheck mep-unknown`	Enables SNMP trap generation for Ethernet CFM continuity check events in relation to the cross-check operation between statically configured MEPs and those learned via CCMs.
Step 13	**end** **Example:** `Router(config)# end`	Returns the router to the privileged EXEC mode.

Provisioning the Network (CE-B)

Complete these steps to configure provisioning the network (CE-B):

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **ethernet cfm domain** *domain-name* **level** *level-id* **[direction outward]**

Step 4 **mep archive-hold-time** *minutes*

Step 5 **exit**

Step 6 **ethernet cfm global**

Step 7 **ethernet cfm ieee**

Step 8 **ethernet cfm traceroute cache**

Step 9 **ethernet cfm traceroute cache size** *entries*

Step 10 **ethernet cfm traceroute cache hold-time** *minutes*

Step 11 **snmp-server enable traps ethernet cfm cc [mep-up] [mep-down] [config] [loop] [cross-connect]**

Step 12 **snmp-server enable traps ethernet cfm crosscheck [mep-unknown] [mep-missing] [service-up]**

Step 13 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters the global configuration mode.
Step 3	**ethernet cfm domain** *domain-name* **level** *level-id* **[direction outward]** **Example:** `Router(config)# ethernet cfm domain Customer level 7 direction outward`	Defines an outward CFM maintenance domain at a particular maintenance level and enters Ethernet CFM configuration mode.
Step 4	**mep archive-hold-time** *minutes* **Example:** `Router(config-ecfm)# mep archive-hold-time 60`	Sets the amount of time that data from a missing MEP is kept in the continuity check database or that entries are held in the error database before they are purged.
Step 5	**exit** **Example:** `Router(config-ecfm)# exit`	Returns the device to global configuration mode.

	Command	Purpose
Step 6	**ethernet cfm global** **Example:** `Router(config)# ethernet cfm global`	Enables CFM processing globally on the device.
Step 7	**ethernet cfm ieee** **Example:** `Router(config)# ethernet cfm ieee`	Enables the CFM IEEE version of CFM. • This command is automatically issued when the ethernet cfm global command is issued.
Step 8	**ethernet cfm traceroute cache** **Example:** `Router(config)# ethernet cfm traceroute cache`	Enables caching of CFM data learned through traceroute messages.
Step 9	**ethernet cfm traceroute cache size** *entries* **Example:** `Router(config)# ethernet cfm traceroute cache size 200`	Sets the maximum size for the CFM traceroute cache table.
Step 10	**ethernet cfm traceroute cache hold-time** *minutes* **Example:** `Router(config)# ethernet cfm traceroute cache hold-time 60`	Sets the amount of time that CFM traceroute cache entries are retained.
Step 11	**snmp-server enable traps ethernet cfm cc [mep-up] [mep-down] [config] [loop] [cross-connect]** **Example:** `Router(config)# snmp-server enable traps ethernet cfm cc mep-up mep-down config loop cross-connect`	Enables SNMP trap generation for Ethernet CFM continuity check events.
Step 12	**snmp-server enable traps ethernet cfm crosscheck [mep-unknown] [mep-missing] [service-up]** **Example:** `Router(config)# snmp-server enable traps ethernet cfm crosscheck mep-unknown`	Enables SNMP trap generation for Ethernet CFM continuity check events in relation to the cross-check operation between statically configured MEPs and those learned via CCMs.
Step 13	**end** **Example:** `Router(config)# end`	Returns the router to the privileged EXEC mode.

Provisioning Service (CE-A)

Perform this task to set up service for Ethernet CFM. Optionally, when this task is completed, you may configure and enable the cross-check function. To perform this optional task, see "Configuring and Enabling the Cross-Check Function (CE-A)".

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **ethernet cfm domain** *domain-name* **level** *level-id*

Step 4 **service** {*ma-name* | *ma-num* | **vlan-id** *vlan-id* | **vpn-id** *vpn-id*} [**port** | **vlan** *vlan-id* [**direction down**]]

Step 5 **continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**]

Step 6 **continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**]

Step 7 **continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**]

Step 8 **exit**

Step 9 **mep archive-hold-time** *minutes*

Step 10 **exit**

Step 11 **ethernet cfm global**

Step 12 **ethernet cfm ieee**

Step 13 **ethernet cfm traceroute cache**

Step 14 **ethernet cfm traceroute cache size** *entries*

Step 15 **ethernet cfm traceroute cache hold-time** *minutes*

Step 16 **interface** *type number*

Step 17 **ethernet cfm mep domain** *domain-name* **mpid** *mpid* {**port** | **vlan** *vlan-id*}

Step 18 **ethernet cfm mep domain** *domain-name* **mpid** *mpid* {**port** | **vlan** *vlan-id*}

Step 19 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters the global configuration mode.

	Command	Purpose
Step 3	**ethernet cfm domain** *domain-name* **level** *level-id* **Example:** `Router(config)# ethernet cfm domain Customer level 7`	Defines a CFM maintenance domain at a particular maintenance level and enters Ethernet CFM configuration mode.
Step 4	**service** {*ma-name* | *ma-num* | **vlan-id** *vlan-id* | **vpn-id** *vpn-id*} [**port** | **vlan** *vlan-id* [**direction down**]] **Example:** `Router(config-ecfm)# service Customer1 vlan 101 direction down`	Configures an MA within a maintenance domain and enters CFM service configuration mode. • If a service is already configured and you configure a new MA name and also specify the **direction down** keyword, a second service is added that maps to the same VLAN. If you configure a new MA name and do not specify the **direction down** keyword, the service is renamed to the new MA name.
Step 5	**continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**] **Example:** `Router(config-ecfm-srv)# continuity-check`	Enables the transmission of CCMs.
Step 6	**continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**] **Example:** `Router(config-ecfm-srv)# continuity-check interval 10`	Configures the time period between CCM transmissions. • The values supported are platform dependent.
Step 7	**continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**] **Example:** `Router(config-ecfm-srv)# continuity-check loss-threshold 10`	Sets the number of CCMs that should be missed before declaring that a remote MEP is down.
Step 8	**exit** **Example:** `Router(config-ecfm-srv)# exit`	Returns the device to Ethernet CFM configuration mode.
Step 9	**mep archive-hold-time** *minutes* **Example:** `Router(config-ecfm)# mep archive-hold-time 60`	Sets the amount of time that data from a missing MEP is kept in the continuity check database or that entries are held in the error database before they are purged.
Step 10	**exit** **Example:** `Router(config-ecfm)# exit`	Returns the device to global configuration mode.

	Command	Purpose
Step 11	**ethernet cfm global** **Example:** `Router(config)# ethernet cfm global`	Enables CFM processing globally on the device.
Step 12	**ethernet cfm ieee** **Example:** `Router(config)# ethernet cfm ieee`	Enables the CFM IEEE version of CFM. • This command is automatically issued when the ethernet cfm global command is issued.
Step 13	**ethernet cfm traceroute cache** **Example:** `Router(config)# ethernet cfm traceroute cache`	Enables caching of CFM data learned through traceroute messages.
Step 14	**ethernet cfm traceroute cache size** *entries* **Example:** `Router(config)# ethernet cfm traceroute cache size 200`	Sets the maximum size for the CFM traceroute cache table.
Step 15	**ethernet cfm traceroute cache hold-time** *minutes* **Example:** `Router(config)# ethernet cfm traceroute cache hold-time 60`	Sets the amount of time that CFM traceroute cache entries are retained.
Step 16	**interface** *type number* **Example:** `Router(config)# interface ethernet 0/3`	Specifies an interface and enters interface configuration mode.
Step 17	**ethernet cfm mep domain** *domain-name* **mpid** *mpid* **{port| vlan** *vlan-id***}** **Example:** `Router(config-if)# ethernet cfm mep domain Customer mpid 701 vlan 100`	Sets a port as internal to a maintenance domain and defines it as a MEP.
Step 18	**ethernet cfm mep domain** *domain-name* **mpid** *mpid* **{port| vlan** *vlan-id***}** **Example:** `Router(config-if)# ethernet cfm mep domain Customer mpid 701 vlan 100`	Sets a port as internal to a maintenance domain and defines it as a MEP.

Step 19	**end**
	
	Example:
	`Router(config-if)# end`
	`Router#`
		Returns the router to the privileged EXEC mode.

Provisioning Service (CE-B)

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **ethernet cfm domain** *domain-name* **level** *level-id* **[direction outward]**

Step 4 **mep archive-hold-time** *minutes*

Step 5 **service** {*ma-name* | *ma-num* | **vlan-id** *vlan-id* | **vpn-id** *vpn-id*} [**port** | **vlan** *vlan-id* [**direction down**]]

Step 6 **continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**]

Step 7 **continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**]

Step 8 **continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**]

Step 9 **exit**

Step 10 **exit**

Step 11 **ethernet cfm global**

Step 12 **ethernet cfm ieee**

Step 13 **ethernet cfm traceroute cache**

Step 14 **ethernet cfm traceroute cache size** *entries*

Step 15 **ethernet cfm traceroute cache hold-time** *minutes*

Step 16 **interface** *type number*

Step 17 **ethernet cfm mep level** *level-id* **[inward | outward domain** *domain-name*] **mpid** *id* **vlan{any |** *vlan-id* **|** *, vlan-id* **|** *vlan-id - vlan-id* **|** *vlan-id - vlan-id***}**

Step 18 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters the global configuration mode.
Step 3	**ethernet cfm domain** *domain-name* **level** *level-id* **[direction outward]** **Example:** `Router(config)# ethernet cfm domain Customer level 7 direction outward`	Defines a CFM maintenance domain at a specified level and enters Ethernet CFM configuration mode.

	Command	Purpose
Step 4	**mep archive-hold-time** *minutes* **Example:** `Router(config-ecfm)# mep archive-hold-time 60`	Sets the amount of time that data from a missing MEP is kept in the continuity check database or that entries are held in the error database before they are purged.
Step 5	**service** {*ma-name* | *ma-num* | **vlan-id** *vlan-id* | **vpn-id** *vpn-id*} [**port** | **vlan** *vlan-id* [**direction down**]] **Example:** `Router(config-ecfm)# service Customer1 vlan 101 direction down`	Configures an MA within a maintenance domain and enters CFM service configuration mode. • If a service is already configured and you configure a new MA name and also specify the **direction down** keyword, a second service is added that maps to the same VLAN. If you configure a new MA name and do not specify the **direction down** keyword, the service is renamed to the new MA name.
Step 6	**continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**] **Example:** `Router(config-ecfm-srv)# continuity-check`	Enables the transmission of CCMs.
Step 7	**continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**] **Example:** `Router(config-ecfm-srv)# continuity-check interval 10`	Configures the time period between CCM transmissions. • The values supported are platform dependent.
Step 8	**continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**] **Example:** `Router(config-ecfm-srv)# continuity-check loss-threshold 10`	Sets the number of CCMs that should be missed before declaring that a remote MEP is down.
Step 9	**exit** **Example:** `Router(config-ecfm-srv)# exit`	Returns the device to Ethernet CFM configuration mode.
Step 10	**exit** **Example:** `Router(config-ecfm)# exit`	Returns the device to global configuration mode.
Step 11	**ethernet cfm global** **Example:** `Router(config)# ethernet cfm global`	Enables CFM processing globally on the device.

	Command	Purpose
Step 12	**ethernet cfm ieee** **Example:** `Router(config)# ethernet cfm ieee`	Enables the CFM IEEE version of CFM. • This command is automatically issued when the **ethernet cfm global** command is issued.
Step 13	**ethernet cfm traceroute cache** **Example:** `Router(config)# ethernet cfm traceroute cache`	Enables caching of CFM data learned through traceroute messages.
Step 14	**ethernet cfm traceroute cache size** *entries* **Example:** `Router(config)# ethernet cfm traceroute cache size 200`	Sets the maximum size for the CFM traceroute cache table.
Step 15	**ethernet cfm traceroute cache hold-time** *minutes* **Example:** `Router(config)# ethernet cfm traceroute cache hold-time 60`	Sets the amount of time that CFM traceroute cache entries are retained.
Step 16	**interface** *type number* **Example:** `Router(config)# interface ethernet 0/3`	Specifies an interface and enters interface configuration mode.
Step 17	**ethernet cfm mep level** *level-id* **[inward | outward domain** *domain-name***] mpid** *id* **vlan{any |** *vlan-id* **| ,** *vlan-id* **|** *vlan-id - vlan-id* **|** *vlan-id - vlan-id***}** **Example:** `Router(config-if)# ethernet cfm mep level 7 outward domain Customer mpid 701 vlan 100`	Provisions an interface as a domain boundary.

Step 18	**end**
	
	Example:
	`Router(config-if)# end`
	`Router#`
		Returns the router to the privileged EXEC mode.

Configuring and Enabling the Cross-Check Function (CE-A)

Perform this task to configure and enable cross-checking for a down MEP. This task requires you to configure and enable cross-checking on two devices. This task is optional.

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **ethernet cfm domain** *domain-name* **level** *level-id*

Step 4 **mep mpid** *mpid*

Step 5 **exit**

Step 6 **ethernet cfm mep crosscheck start-delay** *delay*

Step 7 **exit**

Step 8 **ethernet cfm mep crosscheck {enable | disable} domain** *domain-name*] **{port | vlan {***vlan-id* | *vlan-id - vlan-id* | *, vlan-id - vlan-id***}}**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router>enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters the global configuration mode.
Step 3	**ethernet cfm domain** *domain-name* **level** *level-id* **Example:** `Router(config)# ethernet cfm domain Customer level 7`	Defines a CFM maintenance domain at a specified level and enters Ethernet CFM configuration mode.
Step 4	**mep mpid** *mpid* **Example:** `Router(config-ecfm)# mep mpid 702`	Statically defines the MEPs within a maintenance association.
Step 5	**exit** **Example:** `Router(config-ecfm)# exit`	Returns the device to global configuration mode.
Step 6	**ethernet cfm mep crosscheck start-delay delay** **Example:** `Router(config)# ethernet cfm mep crosscheck start-delay 60`	Configures the maximum amount of time that the device waits for remote MEPs to come up before the cross-check operation is started.

	Command	Purpose
Step 7	**exit** **Example:** `Router(config)# exit`	Returns the device to privileged EXEC mode.
Step 8	**ethernet cfm mep crosscheck {enable | disable} domain** *domain-name*] **{port | vlan {***vlan-id* | *vlan-id - vlan-id* | **,** *vlan-id - vlan-id***}}** **Example:** `Router# ethernet cfm mep crosscheck enable domain cust4 vlan 100`	Enables cross-checking between the list of configured remote MEPs of a domain and MEPs learned through CCMs.

Configuring and Enabling the Cross-Check Function (CE-B)

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **ethernet cfm domain** *domain-name* **level** *level-id*

Step 4 **mep mpid** *mpid*

Step 5 **exit**

Step 6 **ethernet cfm mep crosscheck start-delay** *delay*

Step 7 **exit**

Step 8 **ethernet cfm mep crosscheck {enable | disable} domain** *domain-name*] **{port | vlan {***vlan-id* | *vlan-id - vlan-id* | , *vlan-id - vlan-id***}}**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router>enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters the global configuration mode.

	Command	Purpose
Step 3	**ethernet cfm domain** *domain-name* **level** *level-id* **Example:** `Router(config)# ethernet cfm domain Customer level 7`	Defines a CFM maintenance domain at a specified level and enters Ethernet CFM configuration mode.
Step 4	**mep mpid** *mpid* **Example:** `Router(config-ecfm)# mep mpid 702`	Statically defines the MEPs within a maintenance association.
Step 5	**exit** **Example:** `Router(config-ecfm)# exit`	Returns the device to global configuration mode.
Step 6	**ethernet cfm mep crosscheck start-delay delay** **Example:** `Router(config)# ethernet cfm mep crosscheck start-delay 60`	Configures the maximum amount of time that the device waits for remote MEPs to come up before the cross-check operation is started.
Step 7	**exit** **Example:** `Router(config)# exit`	Returns the device to privileged EXEC mode.
Step 8	**ethernet cfm mep crosscheck {enable | disable} domain** *domain-name*] **{port | vlan {***vlan-id* | *vlan-id - vlan-id* | **,** *vlan-id - vlan-id***}}** **Example:** `Router# ethernet cfm mep crosscheck enable domain cust4 vlan 100`	Enables cross-checking between the list of configured remote MEPs of a domain and MEPs learned through CCMs.

Configuration Examples for Configuring Ethernet CFM for the Cisco ISR G2 Routers

The following two examples show configurations for a network. Configurations are shown not only for the Carrier Ethernet Cisco ISR G2 Routers, but also for the devices used at the access and core of the service provider's network.

- Example: Provisioning a Network, page 81
- Example: Provisioning Service, page 84

Example: Provisioning a Network

This configuration example shows only CFM-related commands. All commands that are required to set up the data path and configure the VLANs on the device are not shown. However, it should be noted that CFM traffic will not flow into or out of the device if the VLANs are not properly configured.

CE-A Configuration

```
!
ethernet cfm global
ethernet cfm ieee
!
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
!
ethernet cfm mip auto-create level 7 vlan 1-4094
!
interface gigabitethernet3/2
 ethernet cfm mip level 7 vlan 101   <<<< Manual MIP
 ethernet cfm mep domain ServiceProvider-L4 mpid 401 vlan 101
 ethernet cfm mep domain OperatorA-L1 mpid 101 vlan 101
!
interface gigabitethernet4/2
 ethernet cfm mip level 1 vlan 101   <<<< Manual MIP
!
snmp-server enable traps ethernet cfm cc mep-up mep-down cross-connect loop config
snmp-server enable traps ethernet cfm crosscheck mep-missing mep-unknown service-up
```

U-PE A Configuration

```
!
ethernet cfm global
ethernet cfm ieee
!
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
!
ethernet cfm mip auto-create level 7 vlan 1-4094
!
interface gigabitethernet3/2
 ethernet cfm mip level 7 vlan 101   <<<< Manual MIP
 ethernet cfm mep domain ServiceProvider-L4 mpid 401 vlan 101
 ethernet cfm mep domain OperatorA-L1 mpid 101 vlan 101
!
interface gigabitethernet4/2
 ethernet cfm mip level 1 vlan 101   <<<< Manual MIP
!
snmp-server enable traps ethernet cfm cc mep-up mep-down cross-connect loop config
snmp-server enable traps ethernet cfm crosscheck mep-missing mep-unknown service-up
```

PE-AGG A Configuration

```
ethernet cfm global
ethernet cfm ieee
ethernet cfm domain OperatorA-L1 level 1
mep archive-hold-time 65
  mip auto-create
  service MetroCustomer1OpA vlan 101
!
interface gigabitethernet3/1
 ethernet cfm mip level 1 vlan 101   <<<< Manual MIP
!
interface gigabitethernet4/1
 ethernet cfm mip level 1    <<<< Manual MIP
```

N-PE A Configuration

```
!
ethernet cfm global
ethernet cfm ieee
!
```

```
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
!
ethernet cfm domain ServiceProvider-L4 level 4
 mep archive-hold-time 60
 mip auto-create
 service MetroCustomer1 vlan 101
  continuity-check
!
ethernet cfm domain OperatorA level 1
mep archive-hold-time 65
 mip auto-create
service MetroCustomer1OpA vlan 101
  continuity-check
!
interface gigabitethernet3/0
 ethernet cfm mip level 1  <<<< manual MIP
!
interface gigabitethernet4/0
 ethernet cfm mip level 4    <<<< manual MIP
!
snmp-server enable traps ethernet cfm cc mep-up mep-down cross-connect loop config
snmp-server enable traps ethernet cfm crosscheck mep-missing mep-unknown service-up
```

U-PE B Configuration

```
!
ethernet cfm global
ethernet cfm ieee
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
!
ethernet cfm domain Customer-L7 level 7
 mip auto-create
 service Customer1 vlan 101 direction down
!
ethernet cfm domain ServiceProvider-L4 level 4
 mep archive-hold-time 60
 service MetroCustomer1 vlan 101
  continuity-check
!
ethernet cfm domain OperatorB level 2
 mip auto-create
 mep archive-hold-time 65
 service MetroCustomer1OpB vlan 101
  continuity-check
!
interface gigabitethernet1/0
 ethernet cfm mip level 7   <<<< manual MIP
!
interface gigabitethernet2/0
 ethernet cfm mip level 2   <<<< manual MIP
!
snmp-server enable traps ethernet cfm cc mep-up mep-down cross-connect loop config
snmp-server enable traps ethernet cfm crosscheck mep-missing mep-unknown service-up
```

PE-AGG B Configuration

```
ethernet cfm global
ethernet cfm ieee
!
ethernet cfm domain OperatorB level 2
```

```
 mep archive-hold-time 65
 mip auto-create
 service MetroCustomer1OpB vlan 101
!
interface gigabitethernet1/1
 ethernet cfm mip level 2   <<<< manual MIP
!
interface gigabitethernet2/1
 ethernet cfm mip level 2   <<<< manual MIP
```

N-PE B Configuration

```
!
ethernet cfm global
ethernet cfm ieee
!
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
!
ethernet cfm domain ServiceProvider level 4
 mep archive-hold-time 60
 mip auto-create
 service MetroCustomer1 vlan 101
  continuity-check
!
ethernet cfm domain OperatorB level 2
 mep archive-hold-time 65
 mip auto-create
 service MetroCustomer1OpB vlan 101
  continuity-check
!
interface gigabitethernet1/2
ethernet cfm mip level 2    <<<< manual MIP
!
interface gigabitethernet2/2
 ethernet cfm mip level 4   <<<< manual MIP
!
snmp-server enable traps ethernet cfm cc mep-up mep-down cross-connect loop config
snmp-server enable traps ethernet cfm crosscheck mep-missing mep-unknown service-up
```

CE-B Configuration

```
!
ethernet cfm global
ethernet cfm ieee
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
!
ethernet cfm domain Customer-L7 level 7
 service Customer1 vlan 101 direction down
  continuity-check
!
snmp-server enable traps ethernet cfm cc mep-up mep-down cross-connect loop config
snmp-server enable traps ethernet cfm crosscheck mep-missing mep-unknown service-up
```

Example: Provisioning Service

CE-A Configuration

```
!
ethernet cfm global
ethernet cfm ieee
```

```
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
!
ethernet cfm domain Customer-L7 level 7
 service Customer1 vlan 101 direction down
  continuity-check
!
interface gigabitethernet3/2
 ethernet cfm mep domain Customer-L7 mpid 701 vlan 101
```

U-PE A Configuration

```
!
ethernet cfm global
ethernet cfm ieee
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
!
ethernet cfm mip auto-create level 7 vlan 1-4094
!
ethernet cfm domain ServiceProvider-L4 level 4
 mep archive-hold-time 60
 service MetroCustomer1 vlan 101
  continuity-check
!
ethernet cfm domain OperatorA-L1 level 1
 mep archive-hold-time 65
 mip auto-create
 service MetroCustomer1OpA vlan 101
  continuity-check
!
interface gigabitethernet3/2
 ethernet cfm mip level 7 vlan 101   <<<< Manual MIP
 ethernet cfm mep domain ServiceProvider-L4 mpid 401 vlan 101
 ethernet cfm mep domain OperatorA-L1 mpid 101 vlan 101
!
interface gigabitethernet4/2
 ethernet cfm mip level 1 vlan 101   <<<< Manual MIP
```

PE-AGG A Configuration

```
ethernet cfm global
ethernet cfm ieee
ethernet cfm domain OperatorA-L1 level 1
mep archive-hold-time 65
  mip auto-create
  service MetroCustomer1OpA vlan 101
!
interface gigabitethernet3/1
 ethernet cfm mip level 1 vlan 101   <<<< Manual MIP
!
interface gigabitethernet4/1
 ethernet cfm mip level 1    <<<< Manual MIP
```

N-PE A Configuration

```
!
ethernet cfm global
ethernet cfm ieee
!
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
```

```
!
ethernet cfm domain ServiceProvider-L4 level 4
 mep archive-hold-time 60
 mip auto-create
 service MetroCustomer1 vlan 101
  continuity-check
!
ethernet cfm domain OperatorA level 1
mep archive-hold-time 65
 mip auto-create
service MetroCustomer1OpA vlan 101
  continuity-check
!
interface gigabitethernet3/0
 ethernet cfm mip level 1    <<<< manual MIP
!
interface gigabitethernet4/0
 ethernet cfm mip level 4    <<<< manual MIP
 ethernet cfm mep domain OperatorA mpid 102 vlan 101
```

U-PE B Configuration

```
!
ethernet cfm global
ethernet cfm ieee
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
!
ethernet cfm domain Customer-L7 level 7
 mip auto-create
 service Customer1 vlan 101 direction down
!
ethernet cfm domain ServiceProvider-L4 level 4
 mep archive-hold-time 60
 service MetroCustomer1 vlan 101
  continuity-check
!
ethernet cfm domain OperatorB level 2
 mep archive-hold-time 65
 service MetroCustomer1OpB vlan 101
  continuity-check
!
interface gigabitethernet1/0
 ethernet cfm mip level 7   <<<< manual MIP
 ethernet cfm mep domain ServiceProvider-L4 mpid 402 vlan 101
 ethernet cfm mep domain OperatorB mpid 201 vlan 101
!
interface gigabitethernet2/0
 ethernet cfm mip level 2   <<<< manual MIP
```

N-PE B Configuration

```
!
ethernet cfm global
ethernet cfm ieee
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
!
ethernet cfm domain ServiceProvider level 4
 mep archive-hold-time 60
 mip auto-create
 service MetroCustomer1 vlan 101
  continuity-check
```

```
!
ethernet cfm domain OperatorB level 2
 mep archive-hold-time 65
 mip auto-create
 service MetroCustomer1OpB vlan 101
  continuity-check
!
interface gigabitethernet1/2
ethernet cfm mip level 2      <<<< manual MIP
!
interface gigabitethernet2/2
 ethernet cfm mip level 4     <<<< manual MIP
 ethernet cfm mep domain OperatorB mpid 202 vlan 101
```

CE-B Configuration

```
!
ethernet cfm global
ethernet cfm ieee
ethernet cfm traceroute cache
ethernet cfm traceroute cache size 200
ethernet cfm traceroute cache hold-time 60
!
ethernet cfm domain Customer-L7 level 7
 service Customer1 vlan 101 direction down
  continuity-check
!
interface gigabitethernet3/2
 ethernet cfm mep domain Customer-L7 mpid 702 vlan 101
```

Support for Y.1731 Performance Monitoring for EVC BD

Y.1731 Performance Monitoring (PM) provides a standard Ethernet PM function that includes measurement of Ethernet frame delay, frame delay variation, frame loss, and frame throughput measurements specified by the ITU-T Y-1731 standard and interpreted by the Metro Ethernet Forum (MEF) standards group.ITU-T Y.1731 feature supports key operation and maintenance standards that provide for automated end-to-end management and monitoring of Ethernet service by service providers.

Note This feature is supported only if you have purchased the DATA technology package functionality (*datak9*) licensing package. For more information about managing software activation licenses on the Cisco ISR and Cisco ISR G2 platforms, see http://www.cisco.com/en/US/docs/routers/access/sw_activation/SA_on_ISR.html.

Configuring a Sender MEP for a Single-Ended Ethernet Delay or Delay Variation Operation

Perform this task to configure a sender MEP on the source device.

Before You Begin

Time synchronization is required between the source and destination devices in order to provide accurate one-way delay (latency) or delay-variation measurements. Configure either Precision Time Protocol (PTP) or Network Time Pprotocol (NTP) on both the source and destination devices.

Note To display information about remote (target) MEPs on destination devices, use the **show ethernet cfm maintenance-points remote** command.

SUMMARY STEPS

Step 1 **enable**

Step 2 **configure terminal**

Step 3 **ip sla** *operation-number*

Step 4 **ethernet y1731 delay dmm domain** *domain-name* {**evc** *evc-id* | **vlan** *vlan-id*} {**mpid** *target-mp-id* | **mac-address** *target-address*} **cos** *cos* {**source** {**mpid** *source-mp-id* | **mac-address** *source-address*}}

Step 5 **clock sync**

Step 6 **aggregate interval** *seconds*

Step 7 **distribution {delay | delay-variation} one-way** *number-of-bins boundary*[,...,*boundary*]

Step 8 **frame interval** *milliseconds*

Step 9 **frame offset** *offset-value*

Step 10 **frame size** *bytes*

Step 11 **history interval** *intervals-stored*

Step 12 **max-delay** *milliseconds*

Step 13 **owner** *owner-id*

Step 14 **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables the privileged EXEC mode. Enter your password when prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters the global configuration mode.
Step 3	**ip sla** *operation-number* **Example:** `Router(config-term)# ip sla 10`	Begins configuring an IP SLAs operation and enters IP SLA configuration mode.

	Command	Purpose
Step 4	**ethernet y1731 delay dmm domain** *domain-name* {**evc** *evc-id* | **vlan** *vlan-id*} {**mpid** *target-mp-id* | **mac-address** *target-address*} **cos** *cos* {**source** {**mpid** *source-mp-id* | **mac-address** *source-address*}} **Example:** `Router(config-ip-sla)# ethernet y1731 delay dmm domain xxx evc yyy mpid 101 cos 4 source mpid 100`	Begins configuring a single-ended Ethernet delay operation and enters IP SLA Y.1731 delay configuration mode.
Step 5	**clock sync** **Example:** `Router(config-sla-y1731-delay)# clock sync`	(Optional) Indicates that the end points are synchronized and thus allows the operation to calculate one-way delay measurements.
Step 6	**aggregate interval** *seconds* **Example:** `Router(config-sla-y1731-delay)# aggregate interval 900`	(Optional) Configures the length of time during which the performance measurements are conducted and the results stored.
Step 7	**distribution {delay | delay-variation} one-way** *number-of-bins boundary[,...,boundary]* **Example:** `Router(config-sla-y1731-delay)# distribution delay-variation one-way 5 5000,10000,15000,20000,-1`	(Optional) Specifies measurement type and configures bins for statistics distributions kept.
Step 8	**frame interval** *milliseconds* **Example:** `Router(config-sla-y1731-delay)# frame interval 100`	(Optional) Sets the gap between successive frames.
Step 9	**frame offset** *offset-value* **Example:** `Router(config-sla-y1731-delay)# frame offset 1`	(Optional) Sets the value for calculating delay variation values.
Step 10	**frame size** *bytes* **Example:** `Router(config-sla-y1731-delay)# frame size 32`	(Optional) Configures padding size for frames.

	Command	Purpose
Step 11	**history interval** *intervals-stored* **Example:** `Router(config-sla-y1731-delay)# history interval 2`	(Optional) Sets the number of statistics distributions kept during the lifetime of an IP SLAs Ethernet operation.
Step 12	**max-delay** *milliseconds* **Example:** `Router(config-sla-y1731-delay)# max-delay 5000`	(Optional) Sets the amount of time an MEP waits for a frame.
Step 13	**owner** *owner-id* **Example:** `Router(config-sla-y1731-delay)# owner admin`	(Optional) Configures the owner of an IP SLAs operation.
Step 14	**end** **Example:** `Router(config-sla-y1731-delay)# end`	Exits to privileged EXEC mode.

What to Do Next

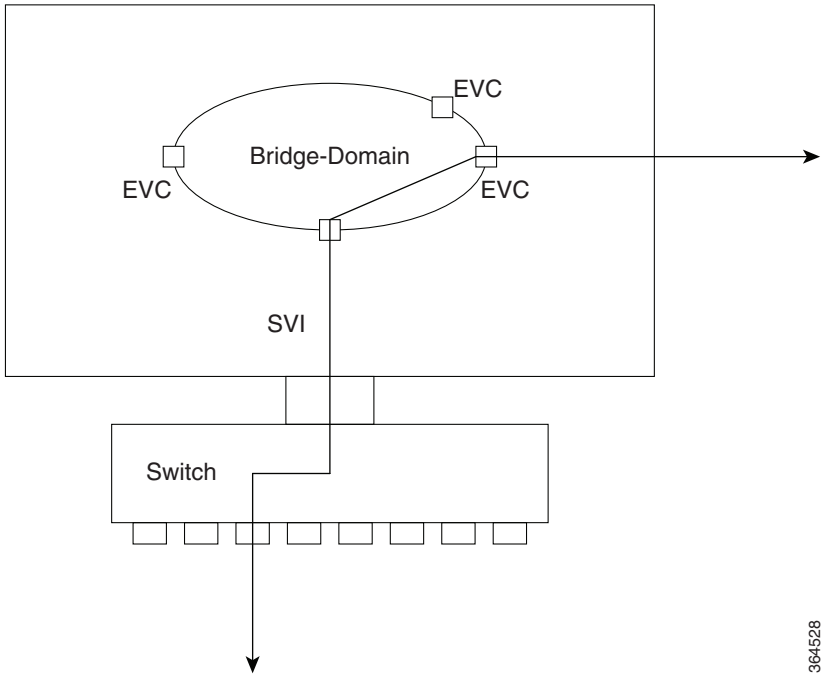
To add proactive threshold conditions and reactive triggering for generating traps, see the "Configuring Proactive Threshold Monitoring" module of the *IP SLAs Configuration Guide*.

When you are finished configuring proactive threshold monitoring for this operation, see the "Scheduling IP SLAs Operations" section to schedule the operation.

Support for Switch Virtual Interfaces (SVI) on ISR G2 Metro Ethernet BD

You can connect a SVI with a Metro Ethernet BD to re-direct the traffic from a switch port onto the BD and vice versa, as shown in Figure 1.

Figure 1 Re-directing the traffic from a SV1 onto the BD and vice versa



Once the SV1 is connected, packets coming into a switch port is re-directed to the SVI and onto the BD. On entering the BD, the source MAC address is learned and the packet is bridged. In the opposite direction, packets coming onto the BD from an EVC via the switch port are directed out the SVI.

Restrictions for SVI support on BDs

- Only one SVI may be associated with a BD.
- There is no EVC (i.e. service instance) configuration on an SVI.
- All packets on the BD, including those from EVCs, should be tagged, with the VLAN tag specifying the VLAN id of the SVI.
- Only access port configurations are supported.

Configuring SVI as Access Port

First you configure the switch port to add an access port SVI to a BD. After this you need to define the associated VLAN interface.

Note The BD id does not have to match the VLAN id in the dot1q tag, but all packets on the BD must be tagged with that VLAN number. So an EVC could be configured in which the BD id matches the VLAN id.

Configuration Examples to add an Access Port SVI to a BD

This example shows how to add an Access Port SVI to a BD:

```
interface GigabitEthernet4
 switchport access vlan 40
```

```
 no ip address
end
```

This example shows how to define the associated VLAN interface:

```
interface Vlan40
 no ip address
 bridge-domain 40
end
```

This example shows the BD id matching with the VLAN id:

```
interface GigabitEthernet8
 no ip address
 duplex auto
 speed auto
 service instance 40 ethernet
 encapsulation dot1q 40
 bridge-domain 40
 !
End
```

EVC Quality of Service (QoS)

For information about EVC QoS, see http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/qos_mqc/configuration/xe-3s/qos-mqc-xe-3s-book/qos-evc.html.

Configuring Backup Data Lines and Remote Management

Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series integrated services routers (ISRs) support remote management and backup data connectivity by means of ISDN.

The following sections describe how to configure backup data lines and remote management:

- Configuring Backup Interfaces, page 93
- Configuring Dial Backup and Remote Management Through the Console Port or Auxiliary Port, page 105
- Configuring Data Line Backup and Remote Management Through the ISDN S/T Port, page 112
- Configuring Third-Party SFPs, page 117

Configuring Backup Interfaces

This section contains the following topics:

- Configuring the Backup Interface, page 93
- Configuring Gigabit Ethernet Failover Media, page 95
- Configuring Cellular Dial-on-Demand Routing Backup, page 97

Configuring the Backup Interface

When the router receives an indication that the primary interface is down, the backup interface is enabled. After the primary connection is restored for a specified period, the backup interface is disabled.

Note For dial-on-demand routing (DDR) backup, even if the backup interface comes out of standby mode, the router does not enable the backup interface unless the router receives the traffic specified for that backup interface.

To configure the router with a backup interface, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **interface** *type number*
2. **backup interface** ***interface-type interface-number***
3. **backup delay** ***enable-delay disable-delay***
4. **exit**

DETAILED STEPS

	Command	Purpose

Step 1	**interface** *type number*
	
	Example:
	`Router(config)# interface atm 0/0/0`
	`Router(config-if)#`
		Enters interface configuration mode for the interface for which you want to configure backup.
		
		The example shows configuration of a backup interface for an ATM WAN connection.

Step 2	**backup interface** *interface-type interface-number*
	
	Example:
	`Router(config-if)# backup interface bri 0/0/1`
	`Router(config-if)#`
		Assigns an interface as the secondary or backup interface.
		
		This can be a serial interface or an asynchronous interface. For example, a serial 1 interface could be configured to back up a serial 0/2/1 interface.
		
		The example shows a BRI interface configured as the backup interface for the ATM 0/0/0 interface.

Step 3	**backup delay** *enable-delay disable-delay* **Example:** `Router(config-if)# backup delay enable delay`	Specifies the delay between the physical interface going down and the backup interface being enabled, and the delay between the physical interface coming back up and the backup interface being disabled.

Step 4	**exit**
	
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits configuration interface mode.

Configuring Gigabit Ethernet Failover Media

Cisco 2921, Cisco 2951, and Cisco 3900 Series routers provide a Gigabit Ethernet (GE) small-form-factor pluggable (SFP) port that supports copper and fiber concurrent connections. Media can be configured for failover redundancy when the network goes down.

Note Do not connect back-to-back Cisco 2921, Cisco 2951, or Cisco 3900 Series routers with failover or as auto-detect configured. This is not a supported configuration and the behavior is unpredictable.

Assigning Primary and Secondary Failover Media

To assign primary and secondary failover media on the GE-SFP port, follow these steps, beginning in EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface gigabitethernet** *slot/port*
3. **media-type sfp**
4. **media-type sfp auto-failover**
5. **end**

DETAILED STEPS

	Command	Purpose

Step 1	**configure terminal**
	
	Example:
	`Router> enable`
	`Router# configure terminal`
	`Router(config)#`
		Enters global configuration mode, when using the console port.
		
		Use the following commands to connect to the router with a remote terminal:
		
		`telnet router name or address`
		`Login: login id`
		`Password: *********`
		`Router> enable`

Step 2	**interface gigabitethernet** *slot/port*
	
	Example:
	`Router(config)# interface gigabitethernet 0/1`
	`Router(config-if)#`
		Enters interface configuration mode.

	Command	Purpose

Step 3	**media-type sfp**
	
	Example:
	`Router(config-if)# media-type sfp`
	`Router(config-if)#`
	
	Example:
	`Router(config-if)# media-type rj45`
	`Router(config-if)#`
		Designates SFP port as the primary media.
		OR
		Designates RJ-45 as the primary media.

Step 4	**media-type sfp auto-failover**
	
	Example:
	`Router(config-if)# media-type sfp`
	`auto-failover`
	`Router(config-if)#`
	
	Example:
	`Router(config-if)# media-type rj45`
	`auto-failover`
	`Router(config-if)#`
		Configures the port with SFP as the primary media for automatic failover from SFP to RJ-45.
		OR
		Configures the port with RJ-45 as the primary media for automatic failover from RJ-45 to SFP.

Step 5	**end**	Exits to global configuration mode.

Enabling Auto-Detect

The Auto-Detect feature is enabled if media-type is not configured. This feature automatically detects which media is connected and links up. If both media are connected, whichever media comes up first is linked up.

Note The Auto-Detect feature only works with 1 GigE SFPs. This feature does not detect 100M SFPs.

Use the **no media-type** command in interface configuration mode to enable the Auto-Detect feature.

To configure the Auto-Detect feature, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface gigabitethernet** *slot/port*
3. **no media-type**

DETAILED STEPS

	Command	Purpose

Step 1	**configure terminal**
	
	Example:
	`Router# configure terminal`
	`Router(config)#`
		Enters global configuration mode.

Step 2	**interface gigabitethernet** *slot/port*
	
	Example:
	`Router(config)# interface gigabitethernet 0/1`
	`Router(config-if)#`
		Enters interface configuration mode.

Step 3	**no media-type**
	
	Example:
	`Router(config-if)# no media-type`
	`GigabitEthernet0/1: Changing media to UNKNOWN.`
	`You may need to update the speed and duplex settings for this interface.`
		Enables Auto-Detect. If a 1 GigE SFP is plugged in, set the speed as 1000 and duplex as full. An RJ45 connection only works with speed as 1000 and duplex as full. If a SFP is not plugged in, all speeds and duplexes are available for the RJ45 media.
		Note Do not set speed as 100 or 10 and duplex as half if a 1 GigE SFP is plugged in. SFP behavior is unpredictable at these settings.

Configuring Cellular Dial-on-Demand Routing Backup

To monitor the primary connection and initiate the backup connection over the cellular interface when needed, the router can use one of the following methods:

- Backup Interface—Backup interface stays in standby mode until the primary interface line protocol is detected as down; then the backup interface is brought up. See the "Configuring Backup Interfaces" section on page 93.
- Dialer Watch—Dialer watch is a backup feature that integrates dial backup with routing capabilities. See the "Configuring DDR Backup Using Dialer Watch" section on page 98.
- Floating Static Route—Route through the backup interface has an administrative distance that is greater than the administrative distance of the primary connection route and therefore is not in the routing table until the primary interface goes down. When the primary interface goes down, the floating static route is used. See the "Configuring DDR Backup Using Floating Static Route" section on page 99.
- Cellular Wireless Modem—To configure the 3G wireless modem as backup with Network Address Translation (NAT) and IPSec on either Global System for Mobile Communications (GSM) or code division multiple access (CDMA) networks, see "Cellular Wireless Modem as Backup with NAT and IPSec Configuration" section on page 100.

Note You cannot configure a backup interface for the cellular interface or any other asynchronous serial interface.

Configuring DDR Backup Using Dialer Watch

To initiate dialer watch, you must configure the interface to perform dial-on-demand routing (DDR) and backup. Use traditional DDR configuration commands, such as **dialer map**, for DDR capabilities. To enable dialer watch on the backup interface and create a dialer list, use the following commands in interface configuration mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *type number*
3. **dialer watch group** *group-number*
4. **dialer watch-list** *group-number* **ip** *ip-address address-mask*
5. **dialer-list** *dialer-group* **protocol** *protocol-name* {**permit** | **deny** | **list** *access-list-number* | **access-group**}
6. **ip access-list** *access list number* **permit** *ip source address*
7. **interface cellular 0**
8. **dialer string** *string*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 2	**interface** *type number* **Example:** `Router (config)# interface ATM 0`	Specifies the interface.
Step 3	**dialer watch-group** *group-number* **Example:** `Router(config-if)# dialer watch-group 2`	Enables dialer watch on the backup interface.
Step 4	**dialer watch-list** *group-number* **ip** *ip-address address-mask* **Example:** `Router(config-if)# dialer watch-list 2 ip 10.4.0.254 255.255.0.0`	Defines a list of all IP addresses to be watched.
Step 5	**dialer-list** *dialer-group* **protocol** *protocol-name* {**permit** | **deny** | **list** *access-list-number* | **access-group**}> **Example:** `Router(config)# dialer-list 2 protocol ip permit`	Creates a dialer list for traffic of interest and permits access to an entire protocol.

	Command or Action	Purpose
Step 6	**ip access-list** *access-list-number* **permit** *ip-source-address* **Example:** `Router(config)# access list 2 permit 10.4.0.0`	Defines traffic of interest. Do not use the **access list permit all** command to avoid sending traffic to the IP network. This may result in call termination.
Step 7	**interface cellular 0** **Example:** `Router (config)# interface cellular 0`	Specifies the cellular interface.

Step 8	**dialer string** *string*
	or
	dialer group *dialer-group-number*
	
	Example:
	`Router (config-if)# dialer string cdma  *** cdma ***`
	
	Example:
	`Router (config-if)# dialer group 2      *** gsm ***`
		CDMA only—**dialer string** *string* specifies the dialer script. (The dialer script is defined by using the **chat script** command).
		GSM only—**dialer group** *dialer-group-number* maps a dialer list to the dialer interface.

Configuring DDR Backup Using Floating Static Route

To configure a floating static default route on the secondary interface, use the following commands, beginning in global configuration mode.

Note Make sure you have IP classless enabled on your router.

SUMMARY STEPS

1. **configure terminal**
2. **ip route** *network-number network-mask* {*ip address* | *interface*} [*administrative-distance*] [**name** *name*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode from the terminal.
Step 2	**ip route** *network-number network-mask* {*ip-address* | *interface*} [*administrative-distance*] [**name** *name*] **Example:** `Router (config)# ip route 0.0.0.0 Dialer 2 track 234`	Establishes a floating static route with the configured administrative distance through the specified interface. A higher administrative distance should be configured for the route through the backup interface, so that the backup interface is used only when the primary interface is down.

Cellular Wireless Modem as Backup with NAT and IPSec Configuration

The following example shows how to configure the 3G wireless modem as backup with NAT and IPsec on either GSM or CDMA networks.

Note The receive and transmit speeds cannot be configured. The actual throughput depends on the cellular network service.

```
Router# sh run
Building configuration...

Current configuration : 5833 bytes
!
! Last configuration change at 18:26:15 UTC Wed Sep 30 2009
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
service internal
!
hostname Router
!
boot-start-marker
boot-end-marker
!
!
no aaa new-model
!
!
!
service-module wlan-ap 0 bootimage autonomous
!
no ipv6 cef
ip source-route
ip cef
!
!
ip multicast-routing
```

```
!
ip dhcp pool miercom
   network 10.1.0.0 255.255.0.0
   default-router 10.1.0.254
   dns-server 10.1.0.254
!
ip dhcp pool wlan-clients
   network 10.9.0.0 255.255.0.0
   default-router 10.9.0.254
   dns-server 10.9.0.254
!
!
!
multilink bundle-name authenticated
!
chat-script gsm ""  "atdt*99#" TIMEOUT 180 "CONNECT"
chat-script cdma "" "atdt#777" TIMEOUT 180 "CONNECT"
!
!
license udi pid CISCO1941W-A/K9 sn FHH1249P016
!
!
archive
 log config
  hidekeys
!
redundancy
!
!
!
track 234 ip sla 1 reachability
!
!
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
 !
!
interface Wlan-GigabitEthernet0/0
 description Internal switch interface connecting to the embedded AP
 !
!
interface GigabitEthernet0/0
 ip address dhcp
 ip virtual-reassembly
 load-interval 30
 shutdown
 duplex auto
 speed auto
 !
!
interface wlan-ap0
 description Service module interface to manage the embedded AP
 ip address 192.168.1.1 255.255.255.0
 arp timeout 0
 no mop enabled
 no mop sysid
 !
!
interface GigabitEthernet0/1
 ip address 10.1.0.254 255.255.0.0
 ip nat inside
 ip virtual-reassembly
 shutdown
```

```
 duplex auto
 speed auto
 crypto ipsec client ezvpn hw-client-pri inside
 crypto ipsec client ezvpn hw-client inside
 !
!
interface Cellular0/0/0
 no ip address
 ip access-group 131 out
 ip nat outside
 ip virtual-reassembly
 encapsulation ppp
 load-interval 30
 dialer in-band
 dialer pool-member 1
 dialer idle-timeout 0
 dialer-group 1
 no peer default ip address
 async mode interactive
 no ppp lcp fast-start
 ppp ipcp dns request
 ppp timeout retry 120
 ppp timeout ncp 30
 fair-queue 64 16 0
 !
 routing dynamic
!
interface ATM0/1/0
 no ip address
 no atm ilmi-keepalive
 no dsl bitswap
 !
!
interface ATM0/1/0.1 point-to-point
 ip virtual-reassembly
 pvc 0/35
  pppoe-client dial-pool-number 2
 !
!
interface Vlan1
 ip address 10.9.0.254 255.255.0.0
 ip nat inside
 ip virtual-reassembly
 !
!
interface Dialer1
 ip address negotiated
 ip access-group 131 out
 ip nat outside
 ip virtual-reassembly
 encapsulation ppp
 load-interval 30
 dialer pool 1
 dialer idle-timeout 0
 dialer string cdma
 dialer persistent
 dialer-group 1
 no peer default ip address
 no ppp lcp fast-start
 ppp chap hostname nousername
 ppp chap password 0 nopassword
 ppp ipcp dns request
 ppp timeout retry 120
 ppp timeout ncp 30
```

```
 fair-queue
 crypto ipsec client ezvpn hw-client
 !
!
interface Dialer2
 ip address negotiated
 ip mtu 1492
 ip nat outside
 ip virtual-reassembly
 encapsulation ppp
 load-interval 30
 dialer pool 2
 dialer idle-timeout 0
 dialer persistent
 dialer-group 2
 ppp authentication chap callin
 ppp chap hostname ciscoenzo2@sbcglobal.net
 ppp chap password 0 Enzo221
 ppp pap sent-username ciscoenzo2@sbcglobal.net password 0 Enzo221
 ppp ipcp dns request
 no cdp enable
 crypto ipsec client ezvpn hw-client-pri
 !
!
ip local policy route-map track-primary-if
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip dns server
ip nat inside source route-map nat2cell interface Dialer1 overload
ip nat inside source route-map nat2dsl interface Dialer2 overload
ip route 0.0.0.0 0.0.0.0 Dialer2 track 234
ip route 0.0.0.0 0.0.0.0 Dialer1 253
!
ip sla 1
 icmp-echo 128.107.248.247 source-interface Dialer2
 frequency 5
ip sla schedule 1 life forever start-time now
access-list 1 permit any
access-list 2 permit 10.1.0.0 0.0.255.255
access-list 100 deny   ip 10.1.0.0 0.0.0.255 10.4.0.0 0.0.0.255
access-list 100 permit ip any any
access-list 101 permit ip 10.0.0.0 0.255.255.255 any
access-list 101 permit ip host 1.1.1.1 any
access-list 102 permit icmp any host 128.107.248.247
access-list 131 deny   ip 10.0.0.0 0.255.255.255 any log-input
access-list 131 permit ip any any
dialer-list 1 protocol ip permit
dialer-list 2 protocol ip permit
!
no cdp run

!
!
!
route-map track-primary-if permit 10
 match ip address 102
 set interface Dialer2 Null0
!
route-map nat2dsl permit 10
 match ip address 101
 match interface Dialer2
```

```
!
route-map nat2cell permit 10
 match ip address 101
 match interface Dialer1
!
!
!
control-plane
 !
!
!
line con 0
 exec-timeout 0 0
line aux 0
line 0/0/0
 exec-timeout 0 0
 script dialer cdma
 login
 modem InOut
 no exec
 transport input all
 transport output all
 autoselect ppp
 rxspeed 3100000
 txspeed 1800000
line 67
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
line vty 0 4
 login
!
exception data-corruption buffer truncate
scheduler allocate 20000 1000
event manager applet pri_back
 event track 234 state any
 action 2.0 cli command "clear ip nat trans forced"
!
end

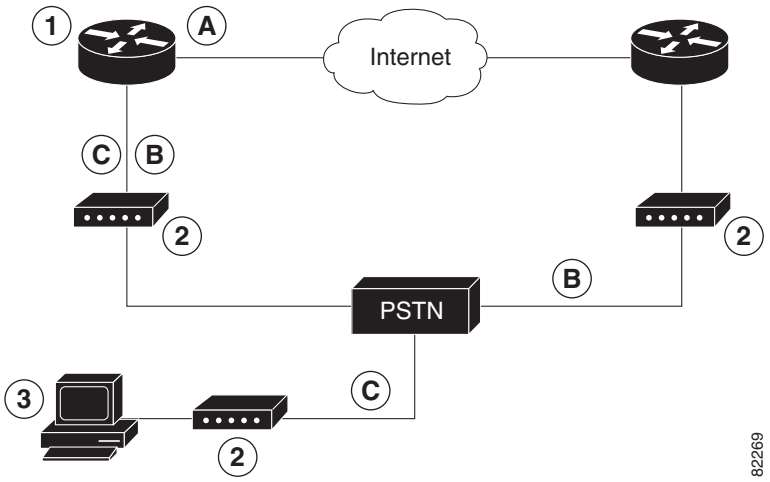
Router#
```

Configuring Dial Backup and Remote Management Through the Console Port or Auxiliary Port

When customer premises equipment, such as a Cisco 3900 series ISR, is connected to an ISP, an IP address is dynamically assigned to the router, or the IP address is assigned by the router peer through the centrally managed function. The dial backup feature can be added to provide a failover route in case the primary line fails. Cisco 3900 series ISRs can use the auxiliary port for dial backup and remote management.

Figure 1 shows the network configuration used for remote management access and for providing backup to the primary WAN line.

Figure 1 Dial Backup and Remote Management Through the Auxiliary Port



1	Cisco 3900 series router	**A**	Main WAN link; primary connection to Internet service provider
2	Modem	**B**	Dial backup; serves as a failover link for Cisco 3900 routers when primary line goes down
3	PC	**C**	Remote management; serves as dial-in access to allow changes or updates to Cisco IOS configurations

To configure dial backup and remote management on Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series ISRs, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **ip name-server** ***server-address***
2. **ip dhcp pool** *name*
3. **exit**
4. **chat-script** *script-name expect-send*
5. **interface** *type number*
6. **exit**
7. **interface** *type number*
8. **dialer watch-group** *group-number*
9. **exit**
10. **ip nat inside source** {**list** *access-list-number*} {**interface** *type number* | **pool** *name*} [**overload**]
11. **ip route** *prefix mask* {*ip-address* | *interface-type interface-number* [*ip-address*]}
12. **access-list** *access-list-number* {**deny** | **permit**} *source* [*source-wildcard*]
13. **dialerwatch-list** *group-number* {**ip** *ip-address address-mask* | **delay route-check initial** *seconds*}
14. **line** [**aux** | **console** | **tty** | **vty**] *line-number* [*ending-line-number*]
15. **modem enable**
16. **exit**
17. **line** [**aux** | **console** | **tty** | **vty**] *line-number* [*ending-line-number*]
18. **flowcontrol** {**none** | **software** [**lock**] [**in** | **out**] | **hardware** [**in** | **out**]}

DETAILED STEPS

	Command	Purpose

Step 1	**ip name-server** *server-address*
	
	Example:
	`Router(config)# ip name-server 192.168.28.12`
	`Router(config)#`
		Enters your ISP DNS IP address.
		
		Tip You may add multiple server addresses if available.

Step 2	**ip dhcp pool** *name*
	
	Example:
	`Router(config)# ip dhcp pool 1`
	`Router(config-dhcp)#`
		Creates a DHCP address pool on the router and enters DHCP pool configuration mode. The *name* argument can be a string or an integer.
		
		Configure the DHCP address pool. For sample commands that you can use in DHCP pool configuration mode, see the "Example" section on page 109.

	Command	Purpose

Step 3	**exit**
	
	Example:
	`Router(config-dhcp)# exit`
	`Router(config)#`
		Exits DHCP pool configuration mode and enters global configuration mode.

Step 4	**chat-script** *script-name expect-send*
	
	Example:
	`Router(config)# chat-script Dialout ABORT ERROR ABORT BUSY "" "AT" OK "ATDT 5555102 T" TIMEOUT 45 CONNECT \c`
	`Router(config)#`
		Configures a chat script for use in DDR to give commands for dialing a modem and for logging in to remote systems. The defined script is used to place a call over a modem connected to the PSTN.

Step 5	**interface** *type number*
	
	Example:
	`Router(config)# interface Async 1`
	`Router(config-if)#`
		Creates asynchronous interface and enters configuration mode for the asynchronous interface.
		
		Configure the asynchronous interface. For sample commands that you can use in asynchronous interface configuration mode, see the "Example" section on page 109.

Step 6	**exit**
	
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits interface configuration mode and enters global configuration mode.

Step 7	**interface** *type number*
	
	Example:
	`Router(config)# interface Dialer 3`
	`Router(config-if)#`
		Creates dialer interface and enters configuration mode for the dialer interface.

Step 8	**dialer watch-group** *group-number*
	
	Example:
	`Router(config-if)# dialer watch-group 1`
	`Router(config-if)#`
		Specifies the group number for the dialer watch list.

Step 9	**exit**
	
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits interface configuration mode and enters global configuration mode.

Step 10	**ip nat inside source** {**list** *access-list-number*} {**interface** *type number* | **pool** *name*} [**overload**] **Example:** `Router(config)# ip nat inside source list 101 interface Dialer 3 overload`	Enables dynamic translation of addresses on the inside interface.

	Command	Purpose

Step 11	**ip route** *prefix mask* {*ip-address* | *interface-type interface-number* [*ip-address*]}
	
	Example:
	`Router(config)# ip route 0.0.0.0 0.0.0.0 22.0.0.2`
	`Router(config)#`
		Sets the IP route to point to the dialer interface as a default gateway.

Step 12	**access-list** *access-list-number* {**deny** | **permit**} *source* [*source-wildcard*] **Example:** `Router(config)# access-list 1 permit 192.168.0.0 0.0.255.255 any`	Defines an extended access list that indicates which addresses need translation.

Step 13	**dialerwatch-list** *group-number* {**ip** *ip-address address-mask* | **delay route-check initial** *seconds*}
	
	Example:
	`Router(config)# dialer watch-list 1 ip 22.0.0.2 255.255.255.255`
	`Router(config)#`
		Evaluates the status of the primary link, based on the existence of routes to the peer. The address 22.0.0.2 is the peer IP address of the ISP.

Step 14	**line** [**aux** | **console** | **tty** | **vty**] *line-number* [*ending-line-number*]
	
	Example:
	`Router(config)# line console 0`
	`Router(config-line)#`
		Enters configuration mode for the line interface.

Step 15	**modem enable**
	
	Example:
	`Router(config-line)# modem enable`
	`Router(config-line)#`
		Switches the port from console port to auxiliary port function.

Step 16	**exit**
	
	Example:
	`Router(config-line)# exit`
	`Router(config)#`
		Exits interface configuration mode.

	Command	Purpose

Step 17	**line** [**aux** | **console** | **tty** | **vty**] *line-number* [*ending-line-number*]
	
	Example:
	`Router(config)# line aux 0`
	`Router(config)#`
		Enters configuration mode for the auxiliary interface.

Step 18	**flowcontrol** {**none** | **software** [**lock**] [**in** | **out**] | **hardware** [**in** | **out**]}
	
	Example:
	`Router(config)# flowcontrol hardware`
	`Router(config)#`
		Enables hardware signal flow control.

Example

The following configuration example specifies an IP address for the ATM interface through PPP and IP Control Protocol (IPCP) address negotiation and specifies dial backup over the console port.

```
!
ip name-server 192.168.28.12
ip dhcp excluded-address 192.168.1.1
!
ip dhcp pool 1
 import all
 network 192.168.1.0 255.255.255.0
 default-router 192.168.1.1
!
! Need to use your own correct ISP phone number.
modemcap entry MY-USER_MODEM:MSC=&F1S0=1
chat-script Dialout ABORT ERROR ABORT BUSY "" "AT" OK "ATDT 5555102\T"
TIMEOUT 45 CONNECT \c
!
!
!
!
interface vlan 1
 ip address 192.168.1.1 255.255.255.0
 ip nat inside
 ip tcp adjust-mss 1452
 hold-queue 100 out
!
! Dial backup and remote management physical interface.
interface Async1
 no ip address
 encapsulation ppp
 dialer in-band
 dialer pool-member 3
 async default routing
 async dynamic routing
 async mode dedicated
 ppp authentication pap callin
!
interface ATM0
 mtu 1492
 no ip address
 no atm ilmi-keepalive
 pvc 0/35
 pppoe-client dial-pool-number 1
```

```
!
dsl operating-mode auto
!
! Primary WAN link.
interface Dialer1
 ip address negotiated
 ip nat outside
 encapsulation ppp
 dialer pool 1
 ppp authentication pap callin
 ppp pap sent-username account password 7 pass
 ppp ipcp dns request
 ppp ipcp wins request
 ppp ipcp mask request
!
! Dialer backup logical interface.
interface Dialer3
 ip address negotiated
 ip nat outside
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 dialer pool 3
 dialer idle-timeout 60
 dialer string 5555102 modem-script Dialout
 dialer watch-group 1
!
! Remote management PC IP address.
peer default ip address 192.168.2.2
no cdp enable
!
! Need to use your own ISP account and password.
ppp pap sent-username account password 7 pass
ppp ipcp dns request
ppp ipcp wins request
ppp ipcp mask request
!
! IP NAT over Dialer interface using route-map.
ip nat inside source route-map main interface Dialer1 overload
ip nat inside source route-map secondary interface Dialer3 overload
ip classless
!
! When primary link is up again, distance 50 will override 80 if dial backup
! has not timed out. Use multiple routes because peer IP addresses are alternated
! among them when the CPE is connected.
ip route 0.0.0.0 0.0.0.0 64.161.31.254 50
ip route 0.0.0.0 0.0.0.0 66.125.91.254 50
ip route 0.0.0.0 0.0.0.0 64.174.91.254 50
ip route 0.0.0.0 0.0.0.0 63.203.35.136 80
ip route 0.0.0.0 0.0.0.0 63.203.35.137 80
ip route 0.0.0.0 0.0.0.0 63.203.35.138 80
ip route 0.0.0.0 0.0.0.0 63.203.35.139 80
ip route 0.0.0.0 0.0.0.0 63.203.35.140 80
ip route 0.0.0.0 0.0.0.0 63.203.35.141 80
ip route 0.0.0.0 0.0.0.0 Dialer1 150
no ip http server
ip pim bidir-enable
!
! PC IP address behind CPE.
access-list 101 permit ip 192.168.0.0 0.0.255.255 any
access-list 103 permit ip 192.168.0.0 0.0.255.255 any
!
! Watch multiple IP addresses because peers are alternated
! among them when the CPE is connected.
```

```
dialer watch-list 1 ip 64.161.31.254 255.255.255.255
dialer watch-list 1 ip 64.174.91.254 255.255.255.255
dialer watch-list 1 ip 64.125.91.254 255.255.255.255
!
! Dial backup will kick in if primary link is not available
! 5 minutes after CPE starts up.
dialer watch-list 1 delay route-check initial 300
dialer-list 1 protocol ip permit
!
! Direct traffic to an interface only if the dialer is assigned an IP address.
route-map main permit 10
 match ip address 101
 match interface Dialer1
!
route-map secondary permit 10
 match ip address 103
 match interface Dialer3
!
! Change console to aux function.
line con 0
 exec-timedout 0 0
 modem enable
 stopbits 1
line aux 0
 exec-timeout 0 0
 ! To enable and communicate with the external modem properly.
 script dialer Dialout
 modem InOut
 modem autoconfigure discovery
 transport input all
 stopbits 1
 speed 115200
 flowcontrol hardware
line vty 0 4
 exec-timeout 0 0
 password cisco
 login
!
scheduler max-task-time 5000
end
```

Starting from Cisco IOS Release 15.3(3)M, if the second core of the CPU was disabled, then you do not need to include **transport input all** command in line 2. If the second core was enabled, then the **transport input all** command is added to the configuration.

```
line 2
 no activation-character
 no exec
 transport preferred none
```

Configuring Data Line Backup and Remote Management Through the ISDN S/T Port

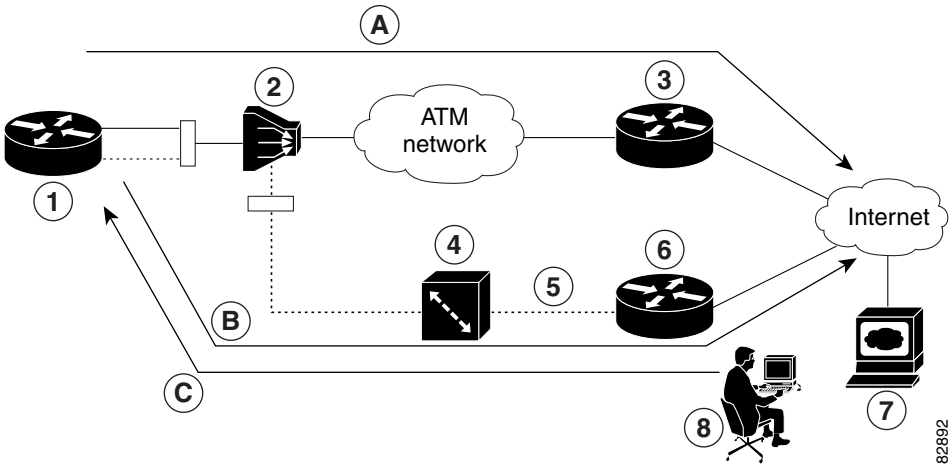
This section contains the following topics:

- Configuring ISDN Settings, page 113
- Example, page 116

Cisco 3900 series routers can use the ISDN S/T port for remote management. Figure 2 and Figure 3 show two typical network configurations that provide remote management access and backup for the primary WAN line.

Figure 2 shows a dial backup link that goes through a customer premises equipment (CPE) splitter, a digital subscriber line access multiplexer (DSLAM), and a central office (CO) splitter before connecting to the ISDN switch.

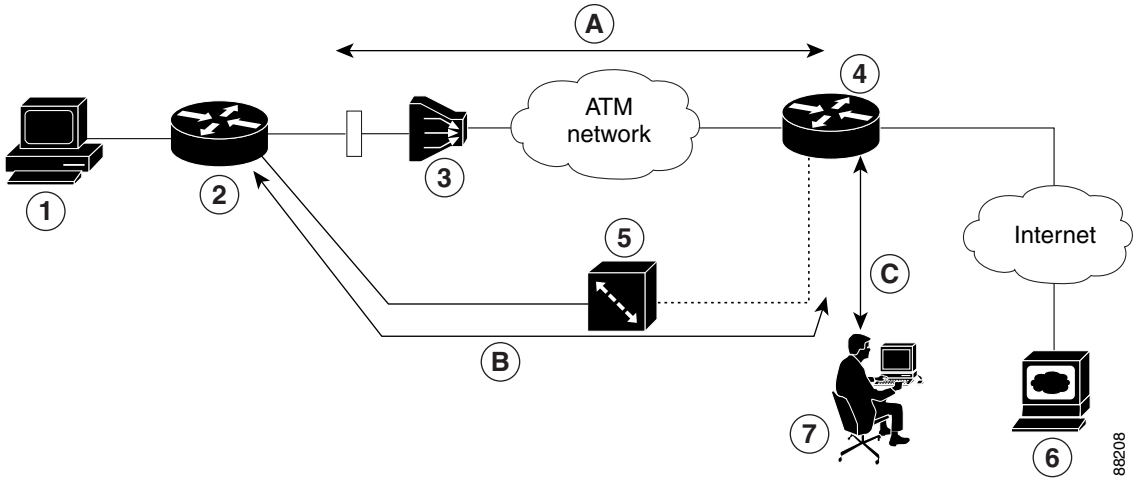
Figure 2 Data Line Backup Through CPE Splitter, DSLAM, and CO Splitter



1	Cisco 3900 series router	**A**	Primary DSL interface, FE interface (Cisco 3900 series router)
2	DSLAM	**B**	Dial backup and remote management through the ISDN interface (ISDN S/T port); serves as a failover link when the primary line goes down
3	ATM aggregator		
4	ISDN switch		
5	ISDN	**C**	Provides administrator with remote management capability through the ISDN interface when the primary DSL link is down; serves as dial-in access to allow changes or updates to Cisco IOS configuration
6	ISDN peer router		
7	Web server		
8	Administrator		

Figure 3 shows a dial backup link that goes directly from the router to the ISDN switch.

Figure 3 Data Line Backup Directly from Router to ISDN Switch



1	PC	**A**	Primary DSL interface
2	Cisco 3900 series ISR	**B**	Dial backup and remote management through the ISDN interface (ISDN S/T port); serves as a failover link when the primary line goes down
3	DSLAM		
4	Aggregator		
5	ISDN switch	**C**	Provides administrator with remote management capability through the ISDN interface when the primary DSL link is down; serves as dial-in access to allow changes or updates to Cisco IOS configuration
6	Web server		
7	Administrator		

Configuring ISDN Settings

Note Traffic of interest must be present in order to activate the backup ISDN line by means of the backup interface and floating static routes methods. Traffic of interest is not needed in order for the dialer watch to activate the backup ISDN line.

To configure your router ISDN interface for use as a backup interface, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **isdn switch-type** *switch-type*
2. **interface** *type number*
3. **encapsulation** *encapsulation-type*
4. **dialer pool-member** *number*
5. **isdn switch-type** *switch-type*
6. **exit**

7. **interface dialer** *dialer-rotary-group-number*
8. **ip address negotiated**
9. **encapsulation** *encapsulation-type*
10. **dialer pool** *number*
11. **dialer string** *dial-string#* [**:***isdn-subaddress*]
12. **dialer-group** *group-number*
13. **exit**
14. **dialer-list** *dialer-group* **protocol** *protocol-name* {**permit** | **deny** | **list** *access-list-number* | *access-group*}

DETAILED STEPS

	Command	Purpose

Step 1	**isdn switch-type** *switch-type*
	
	Example:
	`Router(config)# isdn switch-type basic-net3`
	`Router(config)#`
		Specifies the ISDN switch type.
		
		The example specifies a switch type used in Australia, Europe, and the United Kingdom. For details on other supported switch types, see *Cisco IOS Dial Technologies Command Reference*.

Step 2	**interface** *type number*
	
	Example:
	`Router(config)# interface bri 0`
	`Router(config-if)#`
		Enters configuration mode for the ISDN BRI.

Step 3	**encapsulation** *encapsulation-type*
	
	Example:
	`Router(config-if)# encapsulation ppp`
	`Router(config-if)#`
		Sets the BRI0 interface encapsulation type.

Step 4	**dialer pool-member** *number*
	
	Example:
	`Router(config-if)# dialer pool-member 1`
	`Router(config-if)#`
		Specifies the dialer pool membership.

Step 5	**isdn switch-type** *switch-type*
	
	Example:
	`Router(config-if)# isdn switch-type basic-net3`
	`Router(config-if)#`
		Specifies the ISDN switch type.

Step 6	**exit**
	
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits interface configuration mode and enters global configuration mode.

	Command	Purpose

Step 7	**interface dialer** *dialer-rotary-group-number*
	
	Example:
	`Router(config)# interface dialer 0`
	`Router(config-if)#`
		Creates a dialer interface (numbered 0 to 255) and enters interface configuration mode.

Step 8	**ip address negotiated**
	
	Example:
	`Router(config-if)# ip address negotiated`
	`Router(config-if)#`
		Specifies that the IP address for the interface is obtained through PPP/IPCP (IP Control Protocol) address negotiation. The IP address is obtained from the peer.

Step 9	**encapsulation** *encapsulation-type*
	
	Example:
	`Router(config-if)# encapsulation ppp`
	`Router(config-if)#`
		Sets the encapsulation type for the interface.

Step 10	**dialer pool** *number*
	
	Example:
	`Router(config-if)# dialer pool 1`
	`Router(config-if)#`
		Specifies the dialer pool to be used.
		In the example, the dialer pool 1 setting associates the dialer 0 interface with the BRI0 interface because the BRI0 dialer pool-member value is 1.

Step 11	**dialer string** *dial-string#* [**:***isdn-subaddress*]
	
	Example:
	`Router(config-if)# dialer string 384040`
	`Router(config-if)#`
		Specifies the telephone number to be dialed.

Step 12	**dialer-group** *group-number*
	
	Example:
	`Router(config-if)# dialer group 1`
	`Router(config-if)#`
		Assigns the dialer interface to a dialer group (1–10).

Step 13	**exit**
	
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits dialer interface configuration mode and enters global configuration mode.

Step 14	**dialer-list** *dialer-group* **protocol** *protocol-name* {**permit** | **deny** | **list** *access-list-number* | *access-group*}
	
	Example:
	`Router(config)# dialer-list 1 protocol ip permit`
	`Router(config)#`
		Creates a dialer list for packets of interest to be forwarded through the specified interface dialer group.
		In the example, dialer-list 1 corresponds to dialer-group 1.
		For details about this command and additional parameters that can be set, see *Cisco IOS Dial Technologies Command Reference*.

Example

The following configuration example configures an aggregated and ISDN peer router.

The aggregator is typically a concentrator router where your Cisco router Asynchronous Transfer Mode (ATM) permanent virtual connection (PVC) terminates. In the following configuration example, the aggregator is configured as a PPP over Ethernet (PPPoE) server.

The ISDN peer router is any router that has an ISDN interface and can communicate through a public ISDN network to reach your Cisco router ISDN interface. The ISDN peer router provides Internet access for your Cisco router during the ATM network downtime.

```
! This portion of the example configures the aggregator.
vpdn enable
no vpdn logging
!
vpdn-group 1
 accept-dialin
 protocol pppoe
 virtual-template 1
!
interface Ethernet3
 description "4700ref-1"
 ip address 40.1.1.1 255.255.255.0
 media-type 10BaseT
!
interface Ethernet4
 ip address 30.1.1.1 255.255.255.0
 media-type 10BaseT
!
interface Virtual-Template1
 ip address 22.0.0.2 255.255.255.0
 ip mtu 1492
 peer default ip address pool adsl
!
interface ATM0
 no ip address
 pvc 1/40
 encapsulation aal5snap
 protocol pppoe
!
no atm limi-keepalive
!
ip local pool adsl 22.0.0.1
ip classless
ip route 0.0.0.0 0.0.0.0 22.0.0.1 50
ip route 0.0.0.0 0.0.0.0 30.1.1.2.80

! This portion of the example configures the ISDN peer.
isdn switch-type basic-net3
!
interface Ethernet0
 ip address 30.1.1.2 255.0.0.0
!
interface BRI0
 description "to 836-dialbackup"
 no ip address
 encapsulation ppp
 dialer pool-member 1
 isdn switch-type basic-net3
!
interface Dialer0
```

```
 ip address 192.168.2.2 255.255.255.0
 encapsulation ppp
 dialer pool 1
 dialer string 384020
 dialer-group 1
 peer default ip address pool isdn
!
ip local pool isdn 192.168.2.1
ip http server
ip classless
ip route 0.0.0.0 0.0.0.0 192.168.2.1
ip route 40.0.0.0 255.0.0.0 30.1.1.1
dialer-list 1 protocol ip permit
```

Configuring Third-Party SFPs

Small Form-Factor Pluggables (SFPs) that are not Cisco certified are called third-party SFPs. Cisco approved means the SFPs have undergone rigorous testing with Cisco products and the SFPs are guaranteed to have 100% compatibility.

Third-party SFPs are manufactured by companies that are not on the Cisco-approved Vendor List (AVL). Currently, Cisco ISR G2 routers support only Cisco-approved SFPs. From Release 15.3(2)T, Cisco ISR G2 routers recognize third-party SFPs.

Note Cisco does not provide any kind of support for the third-party SFPs because they are not validated by Cisco.

Restrictions

- Supports only 100BASE SFPs and 1000BASE SFPs under two speed configurations:
  - 100 Mbps speed for 100BASE SFPs
  - 1000 Mbps speed for 1000BASE SFPs
- Only the following routers and modules support third-party SFPs:
  - Cisco 2921 Integrated Services Router
  - Cisco 2951 Integrated Services Router
  - Cisco 3900 Integrated Services Router
  - Cisco 3900E Series Integrated Services Routers
  - Cisco 892-F Gigabit Ethernet Security Router
  - Cisco 898-EA Gigabit Ethernet Security Router
  - EHWIC-1GE-SFP

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **service unsupported-transceiver**
4. **interface** *type slot/subslot/port number*

5. **media-type sfp**
6. **speed** *value*
7. **shutdown**
8. **no shutdown**
9. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables the privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters the global configuration mode.
Step 3	**service unsupported-transceiver** **Example:** `Router(config)# service unsupported-transceiver`	Enables third-party SFP support.
Step 4	**interface** *type slot/subslot/port number* **Example:** `Router(config)# interface ethernet 0/3/0`	Selects an interface to configure.
Step 5	**media-type sfp** **Example:** `Router(config-if)# media-type sfp`	Changes media type to SFP.
Step 6	**speed** *value* **Example:** `Router(config-if)# speed 100`	Configures the speed of the interface. **Note** For 100BASE SFPs, configure the speed to 100 Mbps only. Similarly, for 1000BASE SFPs, configure the speed to 1000 Mbps only.
Step 7	**shutdown** **Example:** `Router(config-if)# shutdown`	Disables the interface, changing its state from administratively UP to administratively DOWN.

	Command or Action	Purpose
Step 8	**no shutdown** **Example:** `Router(config-if)# no shutdown`	Enables the interface, changing its state from administratively DOWN to administratively UP.

Step 9	**exit**
	
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits the configuration mode and returns the global configuration mode.

Examples

This example shows how to configure a third-party SFP on a Cisco ISR G2 Series Router:

```
Router# configure terminal
Router(config-if)# service unsupported-transceiver
Router(config)# interface ethernet 0/3/0
Router(config-if)# media-type sfp
Router(config-if)# speed 100
Router(config-if)# shutdown
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)# exit
```

Configuring Power Efficiency Management

The Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series integrated services routers generation 2 (ISR G2) have hardware and software features for reducing power consumption. The hardware features include high-efficiency AC power supplies and electrical components with built-in power saving features, such as RAM select and clock gating. See your router's hardware installation guide for more information on these hardware features. The software features include EnergyWise, a power efficiency management feature that will power down unused modules, and disable unused clocks to the modules and peripherals on the router. ISR G2s must be running Cisco IOS Release 15.0(1)M or later to support EnergyWise. Detailed configuration procedures are included in the *Cisco EnergyWise Configuration Guide*, which can be found at Cisco.com.

The following sections provide general information about the EnergyWise feature running on ISR G2s:

- Modules and Interface Supporting EnergyWise, page 121
- Restrictions for Power Efficiency Management and OIR, page 122

Modules and Interface Supporting EnergyWise

Table 1 lists the modules and interface cards that are supported for use with EnergyWise at the time of this product release.

Table 1 Modules that Support the Power Efficiency Management Feature

Type of Module	Module Name
SM	SM-ES2-16-P
	SM-SRE
NM	NM-16-ESW[1]
NME	NME-16ES-1G-P
HWIC	HWIC-4ESW-POE
	HWIC-1G-SFP
	HWIC-2FE
ISM	ISM-SRE-300-K9
PVDM3	PVDM3-256
SRE	SM-SRE-700-K9

1. NM-16ESW is not supported on Cisco 3945E and Cisco 3925E.

Restrictions for Power Efficiency Management and OIR

The following restrictions apply when using the power efficiency management feature:

- The online insertion and removal (OIR) commands cannot be used when a module is in power save mode.
- When the OIR commands are executed, power efficiency management cannot be configured on a service module.

Configuring Security Features

Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series integrated services routers (ISRs) provide the following security features:

- Configuring the Cryptographic Engine Accelerator, page 123
- Configuring SSL VPN, page 123
- Authentication, Authorization, and Accounting, page 124
- Configuring AutoSecure, page 124
- Configuring Access Lists, page 125
- Configuring Cisco IOS Firewall, page 126
- Zone-Based Policy Firewall, page 126
- Configuring Cisco IOS IPS, page 127
- Content Filtering, page 127
- Configuring VPN, page 127
- Configuring Dynamic Multipoint VPN, page 145
- Configuring Group Encrypted Transport VPN, page 146

Configuring the Cryptographic Engine Accelerator

Services Performance Engine 200 and Services Performance Engine 250 have an onboard cryptographic engine accelerator that is shared between SSLVPN and IPSec protocols.

By default, acceleration of SSL is disabled so IPSec performance is maximized. To set up a router as an SSLVPN gateway, enable hardware acceleration for SSLVPN with the **crypto engine accelerator bandwidth-allocation ssl fair** command from global configuration mode. Issue the **reload** command.

Configuring SSL VPN

The Secure Socket Layer Virtual Private Network (SSL VPN) feature (also known as WebVPN) provides support, in Cisco IOS software, for remote user access to enterprise networks from anywhere on the Internet. Remote access is provided through a SSL–enabled SSL VPN gateway. The SSL VPN gateway allows remote users to establish a secure VPN tunnel using a web browser. This feature provides a

comprehensive solution that allows easy access to a broad range of web resources and web-enabled applications using native HTTP over SSL (HTTPS) browser support. SSL VPN delivers three modes of SSL VPN access: clientless, thin-client, and full-tunnel client support.

For additional information about configuring SSL VPN, see the "SSL VPN" section of *Cisco IOS Security Configuration Guide: Secure Connectivity, Release 12.4T* at: http://www.cisco.com/en/US/docs/ios/sec_secure_connectivity/configuration/guide/12_4t/sec_secure_connectivity_12_4t_book.html.

Authentication, Authorization, and Accounting

Authentication, Authorization, and Accounting (AAA) network security services provide the primary framework through which you set up access control on your router. Authentication provides the method of identifying users, including login and password dialog, challenge and response, messaging support, and, depending on the security protocol you choose, encryption. Authorization provides the method for remote access control, including one-time authorization or authorization for each service, per-user account list and profile, user group support, and support of IP, Internetwork Packet Exchange (IPX), AppleTalk Remote Access (ARA), and Telnet. Accounting provides the method for collecting and sending security server information used for billing, auditing, and reporting, such as user identities, start and stop times, executed commands (such as PPP), number of packets, and number of bytes.

AAA uses protocols such as Remote Authentication Dial-In User Service (RADIUS), Terminal Access Controller Access Control System Plus (TACACS+), or Kerberos to administer its security functions. If your router is acting as a network access server, AAA is the means through which you establish communication between your network access server and your RADIUS, TACACS+, or Kerberos security server.

For information about configuring AAA services and supported security protocols, authentication authorization, accounting, RADIUS, TACACS+, or Kerberos, see the following sections of *Cisco IOS Security Configuration Guide: Securing User Services, Release 12.4T* at:

http://www.cisco.com/en/US/docs/ios/sec_user_services/configuration/guide/12_4T/sec_securing_user_services_12.4t_book.html:

- Configuring Authentication
- Configuring Authorization
- Configuring Accounting
- Configuring RADIUS
- Configuring TACACS+
- Configuring Kerberos

Configuring AutoSecure

The AutoSecure feature disables common IP services that can be exploited for network attacks and enables IP services and features that can aid in the defense of a network when under attack. These IP services are all disabled and enabled simultaneously with a single command, greatly simplifying security configuration on your router. For a complete description of the AutoSecure feature, see the *AutoSecure* feature document at: http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123_1/ftatosec.htm.

Configuring Access Lists

Access lists permit or deny network traffic over an interface, based on source IP address, destination IP address, or protocol. Access lists are configured as standard or extended. A standard access list either permits or denies passage of packets from a designated source. An extended access list allows designation of both the destination and the source, and it allows designation of individual protocols to be permitted or denied passage.

For more complete information on creating access lists, see the "Access Control Lists" section of *Cisco IOS Security Configuration Guide: Securing the Data Plane, Release 12.4T* at: http://www.cisco.com/en/US/docs/ios/sec_data_plane/configuration/guide/12_4t/sec_data_plane_12_4t_book.html.

An access list is a series of commands with a common tag to bind them together. The tag is either a number or a name. Table 1 lists the commands used to configure access lists.

Table 1 Access List Configuration Commands

Access Control List (ACL) Type	Configuration Commands
Numbered	
Standard	**access-list** {**1-99**}{**permit** | **deny**} *source-addr* [*source-mask*]
Extended	**access-list** {**100-199**}{**permit** | **deny**} *protocol source-addr* [*source-mask*] *destination-addr* [*destination-mask*]
Named	
Standard	**ip access-list standard** *name* **deny** {*source* | *source-wildcard* | **any**}
Extended	**ip access-list extended** *name* **{permit | deny}** *protocol* {*source-addr* [*source-mask*] | **any**}{*destination-addr* [*destination-mask*] | **any**}

To create, refine, and manage access lists, see the following sections of the "Access Control Lists" section of *Cisco IOS Security Configuration Guide: Securing the Data Plane, Release 12.4T* at: http://www.cisco.com/en/US/docs/ios/sec_data_plane/configuration/guide/12_4t/sec_data_plane_12_4t_book.html:

- Creating an IP Access List and Applying It to an Interface
- Creating an IP Access List to Filter IP Options, TCP Flags, Noncontiguous Ports, or TTL Values
- Refining an IP Access List
- Displaying and Clearing IP Access List Data Using ACL Manageability

Access Groups

An access group is a sequence of access list definitions bound together with a common name or number. An access group is enabled for an interface during interface configuration. Use the following guidelines when creating access groups:

- The order of access list definitions is significant. A packet is compared against the first access list in the sequence. If there is no match (that is, if neither a permit nor a deny occurs), the packet is compared with the next access list, and so on.
- All parameters must match the access list before the packet is permitted or denied.
- There is an implicit "deny all" at the end of all sequences.

For information on configuring and managing access groups, see the "Creating an IP Access List to Filter IP Options, TCP Flags, Noncontiguous Ports, or TTL Values" section of the "Access Control Lists" section of *Cisco IOS Security Configuration Guide: Securing the Data Plane, Release 12.4T* at: http://www.cisco.com/en/US/docs/ios/sec_data_plane/configuration/guide/12_4t/sec_data_plane_12_4t_book.html.

Configuring Cisco IOS Firewall

The Cisco IOS Firewall lets you configure a stateful firewall where packets are inspected internally and the state of network connections is monitored. Stateful firewall is superior to static access lists because access lists can only permit or deny traffic based on individual packets, not based on streams of packets. Also, because the Cisco IOS Firewall inspects the packets, decisions to permit or deny traffic can be made by examining application layer data, which static access lists cannot examine.

To configure a Cisco IOS Firewall, specify which protocols to examine by using the following command in interface configuration mode:

ip inspect name *inspection-name protocol* **timeout** *seconds*

When inspection detects that the specified protocol is passing through the firewall, a dynamic access list is created to allow the passage of return traffic. The timeout parameter specifies the length of time that the dynamic access list remains active without return traffic passing through the router. When the timeout value is reached, the dynamic access list is removed, and subsequent packets (possibly valid ones) are not permitted.

Use the same inspection name in multiple statements to group them into one set of rules. This set of rules can be activated elsewhere in the configuration by using the **ip inspect inspection-name { in | out }** command when you configure an interface at the firewall.

For additional information about configuring a Cisco IOS Firewall, see *"Cisco IOS Firewall Overview"* at: http://www.cisco.com/en/US/docs/ios/security/configuration/guide/sec_ios_firewall_ov.html.

The Cisco IOS Firewall may also be configured to provide voice security in Session Initiated Protocol (SIP) applications. SIP inspection provides basic inspection functionality (SIP packet inspection and detection of pinhole openings), as well protocol conformance and application security. For more information, see *"Cisco IOS Firewall: SIP Enhancements: ALG and AIC"* at: http://www.cisco.com/en/US/docs/ios/security/configuration/guide/sec_sip_alg_aic.html.

Zone-Based Policy Firewall

The Cisco IOS Zone-Based Policy Firewall can be used to deploy security policies by assigning interfaces to different zones and configuring a policy to inspect the traffic moving between these zones. The policy specifies a set of actions to be applied on the defined traffic class.

For additional information about configuring zone-based policy firewall, see the "Zone-Based Policy Firewall" section of *Cisco IOS Security Configuration Guide: Securing the Data Plane, Release 12.4T* at: http://www.cisco.com/en/US/docs/ios/sec_data_plane/configuration/guide/12_4t/sec_data_plane_12_4t_book.html.

Configuring Cisco IOS IPS

Cisco IOS Intrusion Prevention System (IPS) technology enhances perimeter firewall protection by taking appropriate action on packets and flows that violate the security policy or represent malicious network activity.

Cisco IOS IPS identifies attacks using "signatures" to detect patterns of misuse in network traffic. Cisco IOS IPS acts as an in-line intrusion detection sensor, watching packets and sessions as they flow through the router, scanning each to match currently active (loaded) attack signatures. When Cisco IOS IPS detects suspicious activity, it responds before network security can be compromised, it logs the event, and, depending on the action(s) configured to be taken for the detected signature(s), it does one of the following:

- Sends an alarm in syslog format or logs an alarm in Secure Device Event Exchange (SDEE) format
- Drops suspicious packets
- Resets the connection
- Denies traffic from the source IP address of the attacker for a specified amount of time
- Denies traffic on the connection for which the signature was seen for a specified amount of time

For additional information about configuring Cisco IOS IPS, see the "Cisco IOS IPS 5.x Signature Format Support and Usability Enhancements" section of *Cisco IOS Security Configuration Guide: Securing the Data Plane, Release 12.4T* at: http://www.cisco.com/en/US/docs/ios/sec_data_plane/configuration/guide/12_4t/sec_data_plane_12_4t_book.html.

Content Filtering

Cisco 3900 series, 2900 series, and 1900 series ISRs provide category-based URL filtering. The user provisions URL filtering on the ISR by selecting categories of websites to be permitted or blocked. An external server, maintained by a third party, is used to check for URLs in each category. Permit and deny policies are maintained on the ISR. The service is subscription based, and the URLs in each category are maintained by the third party vendor.

For additional information about configuring URL filtering, see "Subscription-based Cisco IOS Content Filtering" at: http://www.cisco.com/en/US/docs/ios/security/configuration/guide/sec_url_filtering.html.

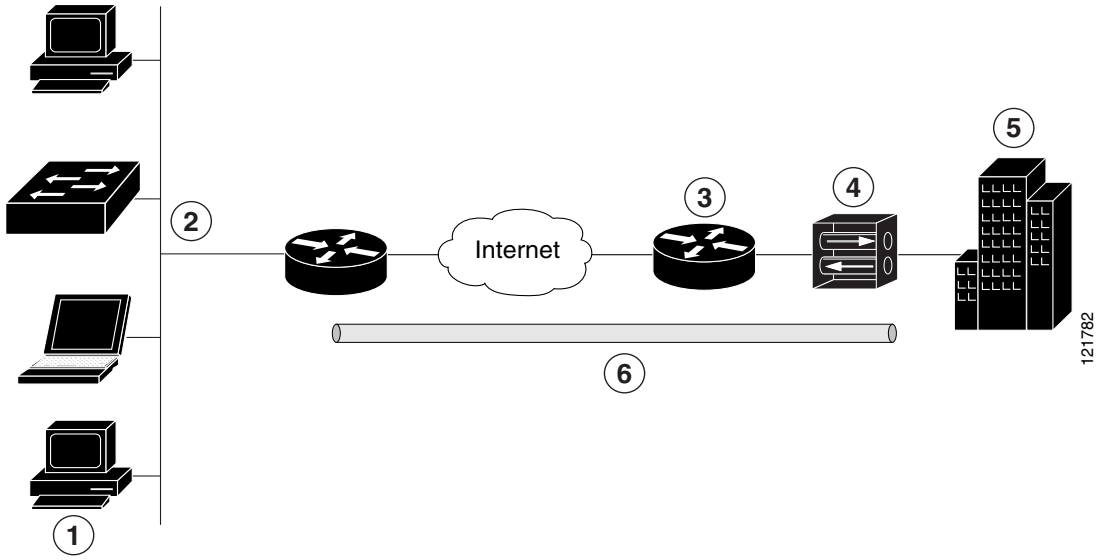
Configuring VPN

A Virtual Private Network (VPN) connection provides a secure connection between two networks over a public network such as the Internet. Cisco 3900 series, 2900 series, and 1900 series ISRs support two types of VPNs: site-to-site and remote access. Remote access VPNs are used by remote clients to log in to a corporate network. Site-to-site VPNs connect branch offices to corporate offices. This section gives an example for each.

Remote Access VPN Example

The configuration of a remote access VPN uses Cisco Easy VPN and an IP Security (IPSec) tunnel to configure and secure the connection between the remote client and the corporate network. Figure 1 shows a typical deployment scenario.

Figure 1 Remote Access VPN Using IPSec Tunnel



1	Remote networked users
2	VPN client—Cisco 3900 series, 2900 series, or 1900 series ISR
3	Router—Provides corporate office network access
4	VPN server—Easy VPN server; for example, a Cisco VPN 3000 concentrator with outside interface address 210.110.101.1
5	Corporate office with a network address of 10.1.1.1
6	IPSec tunnel

The Cisco Easy VPN client feature eliminates much of the tedious configuration work by implementing the Cisco Unity Client protocol. This protocol allows most VPN parameters, such as internal IP addresses, internal subnet masks, DHCP server addresses, Windows Internet Naming Service (WINS) server addresses, and split-tunneling flags, to be defined at a VPN server, such as a Cisco VPN 3000 series concentrator that is acting as an IPSec server.

A Cisco Easy VPN server–enabled device can terminate VPN tunnels initiated by mobile and remote workers who are running Cisco Easy VPN Remote software on PCs. Cisco Easy VPN server–enabled devices allow remote routers to act as Cisco Easy VPN Remote nodes.

The Cisco Easy VPN client feature can be configured in one of two modes—client mode or network extension mode. Client mode is the default configuration and allows only devices at the client site to access resources at the central site. Resources at the client site are unavailable to the central site. Network extension mode allows users at the central site (where the Cisco VPN 3000 series concentrator is located) to access network resources on the client site.

After the IPSec server has been configured, a VPN connection can be created with minimal configuration on an IPSec client. When the IPSec client initiates the VPN tunnel connection, the IPSec server pushes the IPSec policies to the IPSec client and creates the corresponding VPN tunnel connection.

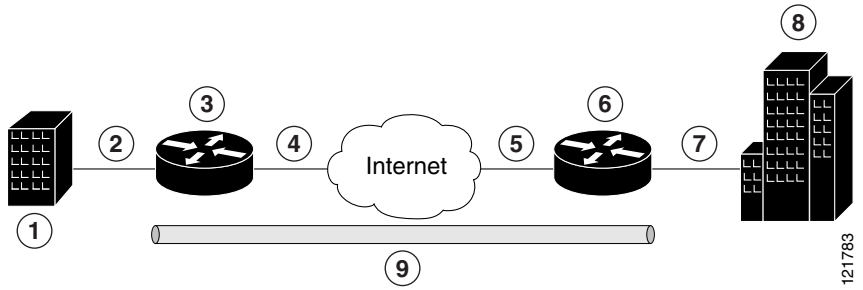
Note The Cisco Easy VPN client feature supports configuration of only one destination peer. If your application requires creation of multiple VPN tunnels, you must manually configure the IPSec VPN and Network Address Translation/Peer Address Translation (NAT/PAT) parameters on both the client and the server.

Cisco 3900 series, 2900 series, and 1900 series ISRs can be also configured to act as Cisco Easy VPN servers, letting authorized Cisco Easy VPN clients establish dynamic VPN tunnels to the connected network. For information on configuring Cisco Easy VPN servers, see the *Easy VPN Server* feature at: http://www.cisco.com/en/US/docs/ios/12_2t/12_2t8/feature/guide/ftunity.html.

Site-to-Site VPN Example

The configuration of a site-to-site VPN uses IPSec and the generic routing encapsulation (GRE) protocol to secure the connection between the branch office and the corporate network. Figure 2 shows a typical deployment scenario.

Figure 2 Site-to-Site VPN Using an IPSec Tunnel and GRE



1	Branch office containing multiple LANs and VLANs
2	Fast Ethernet LAN interface—With address 192.165.0.0/16 (also the inside interface for NAT)
3	VPN client—Cisco 3900 series, 2900 series, or 1900 series ISR
4	Fast Ethernet or ATM interface—With address 200.1.1.1 (also the outside interface for NAT)
5	LAN interface—Connects to the Internet; with outside interface address of 210.110.101.1
6	VPN client—Another router, which controls access to the corporate network
7	LAN interface—Connects to the corporate network; with inside interface address of 10.1.1.1
8	Corporate office network
9	IPSec tunnel with GRE

For more information about IPSec and GRE configuration, see the Configuring Security for VPNs with IPSec" chapter of *Cisco IOS Security Configuration Guide: Secure Connectivity, Release 12.4T* at: http://www.cisco.com/en/US/docs/ios/sec_secure_connectivity/configuration/guide/12_4t/sec_secure_connectivity_12_4t_book.html.

Configuration Examples

Each example configures a VPN over an IPSec tunnel, using the procedure given in the "Configure a VPN over an IPSec Tunnel" section on page 130. Then, the specific procedure for a remote access configuration is given, followed by the specific procedure for a site-to-site configuration.

The examples shown in this chapter apply only to the endpoint configuration on the Cisco 3900 series, 2900 series, and 1900 series ISRs. Any VPN connection requires both endpoints to be properly configured in order to function. See the software configuration documentation as needed to configure VPN for other router models.

VPN configuration information must be configured on both endpoints. You must specify parameters such as internal IP addresses, internal subnet masks, DHCP server addresses, and Network Address Translation (NAT).

- "Configure a VPN over an IPSec Tunnel" section on page 130
- "Create a Cisco Easy VPN Remote Configuration" section on page 139
- "Configure a Site-to-Site GRE Tunnel" section on page 142

Configure a VPN over an IPSec Tunnel

Perform the following tasks to configure a VPN over an IPSec tunnel:

- Configure the IKE Policy, page 131
- Configure Group Policy Information, page 132
- Apply Mode Configuration to the Crypto Map, page 134
- Enable Policy Lookup, page 135
- Configure IPSec Transforms and Protocols, page 136
- Configure the IPSec Crypto Method and Parameters, page 137
- Apply the Crypto Map to the Physical Interface, page 138
- Where to Go Next, page 139

Configure the IKE Policy

To configure the Internet Key Exchange (IKE) policy, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **crypto isakmp policy** *priority*
2. **encryption** {**des** | **3des** | **aes** | **aes 192** | **aes 256**}
3. **hash** {**md5** | **sha**}
4. **authentication** {**rsa-sig** | **rsa-encr** | **pre-share**}
5. **group** {**1** | **2** | **5**}
6. **lifetime** *seconds*
7. **exit**
8.

DETAILED STEPS

	Command or Action	Purpose

Step 1	**crypto isakmp policy** *priority*
	
	Example:
	`Router(config)# crypto isakmp policy 1`
	`Router(config-isakmp)#`
		Creates an IKE policy that is used during IKE negotiation. The priority is a number from 1 to 10000, with 1 being the highest.
		
		Also enters the ISAKMP[1] policy configuration mode.

Step 2	**encryption** {**des**	**3des**	**aes**	**aes 192**	**aes 256**}
					
					Example:
					`Router(config-isakmp)# encryption 3des`
					`Router(config-isakmp)#`
						Specifies the encryption algorithm used in the IKE policy.
						
						The example specifies 168-bit DES[2].

Step 3	**hash** {**md5**	**sha**}
		
		Example:
		`Router(config-isakmp)# hash md5`
		`Router(config-isakmp)#`
			Specifies the hash algorithm used in the IKE policy.
			
			The example specifies the MD5[3] algorithm. The default is SHA-1[4].

Step 4	**authentication** {**rsa-sig**	**rsa-encr**	**pre-share**}
			
			Example:
			`Router(config-isakmp)# authentication pre-share`
			`Router(config-isakmp)#`
				Specifies the authentication method used in the IKE policy.
				
				The example specifies a pre-shared key.

Step 5	**group** {**1**	**2**	**5**}
			
			Example:
			`Router(config-isakmp)# group 2`
			`Router(config-isakmp)#`
				Specifies the Diffie-Hellman group to be used in an IKE policy.

	Command or Action	Purpose

Step 6	**lifetime** *seconds*
	
	Example:
	`Router(config-isakmp)# lifetime 480`
	`Router(config-isakmp)#`
		Specifies the lifetime, from 60 to 86400 seconds, for an IKE SA[5].

Step 7	**exit**
	
	Example:
	`Router(config-isakmp)# exit`
	`Router(config)#`
		Exits IKE policy configuration mode and enters global configuration mode.

1. ISAKMP = Internet Security Association Key and Management Protocol
2. DES = data encryption standard
3. MD5 = Message Digest 5
4. SHA-1 = Secure Hash standard
5. SA = security association

Configure Group Policy Information

To configure the group policy, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **crypto isakmp client configuration group** {*group-name* | *default*}
2. **key** ***name***
3. **dns** ***primary-server***
4. **domain** ***name***
5. **exit**
6. **ip local pool {default | *poolname*} [*low-ip-address* [*high-ip-address*]]**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**crypto isakmp client configuration group** {*group-name*	*default*}
		
		Example:
		`Router(config)# crypto isakmp client configuration group rtr-remote`
		`Router(config-isakmp-group)#`
			Creates an IKE policy group containing attributes to be downloaded to the remote client.
			
			Also enters the ISAKMP group policy configuration mode.

Step 2	**key** *name*
	
	Example:
	`Router(config-isakmp-group)# key secret-password`
	`Router(config-isakmp-group)#`
		Specifies the IKE pre-shared key for the group policy.

	Command or Action	Purpose

Step 3	**dns** *primary-server*
	
	Example:
	`Router(config-isakmp-group)# dns 10.50.10.1`
	`Router(config-isakmp-group)#`
		Specifies the primary DNS[1] server for the group.
		You may also want to specify WINS[2] servers for the group by using the **wins** command.

Step 4	**domain** *name*
	
	Example:
	`Router(config-isakmp-group)# domain company.com`
	`Router(config-isakmp-group)#`
		Specifies group domain membership.

Step 5	**exit**
	
	Example:
	`Router(config-isakmp-group)# exit`
	`Router(config)#`
		Exits IKE group policy configuration mode and enters global configuration mode.

Step 6	**ip local pool** {**default** | *poolname*} [*low-ip-address* [*high-ip-address*]]
	
	Example:
	`Router(config)# ip local pool dynpool 30.30.30.20 30.30.30.30`
	`Router(config)#`
		Specifies a local address pool for the group.
		For details about this command and additional parameters that can be set, see *Cisco IOS Dial Technologies Command Reference*.

1. DNS = Domain Name System
2. WINS = Windows Internet Naming Service

Apply Mode Configuration to the Crypto Map

To apply mode configuration to the crypto map, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **crypto map** *map-name* **isakmp authorization list** *list-name*
2. **crypto map** *tag* **client configuration address** [**initiate** | **respond**]

DETAILED STEPS

	Command or Action	Purpose

Step 1	**crypto map** *map-name* **isakmp authorization list** *list-name*
	
	Example:
	`Router(config)# crypto map dynmap isakmp authorization list rtr-remote`
	`Router(config)#`
		Applies mode configuration to the crypto map and enables key lookup (IKE queries) for the group policy from an AAA server.

Step 2	**crypto map** *tag* **client configuration address** [**initiate**	**respond**]
		
		Example:
		`Router(config)# crypto map dynmap client configuration address respond`
		`Router(config)#`
			Configures the router to reply to mode configuration requests from remote clients.

Enable Policy Lookup

To enable policy lookup through AAA, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **aaa new-model**
2. **aaa authentication login** {**default** | *list-name*} *method1* [*method2...*]
3. **aaa authorization** {**network** | **exec** | **commands** *level* | **reverse-access** | **configuration**} {**default** | *list-name*} [*method1* [*method2...*]]
4. **username** *name* {**nopassword** | **password** *password* | **password** *encryption-type encrypted-password*}

DETAILED STEPS

	Command or Action	Purpose

Step 1	**aaa new-model**
	
	Example:
	`Router(config)# aaa new-model`
	`Router(config)#`
		Enables the AAA access control model.

Step 2	**aaa authentication login** {**default**	*list-name*} *method1* [*method2...*]
		
		Example:
		`Router(config)# aaa authentication login rtr-remote local`
		`Router(config)#`
			Specifies AAA authentication of selected users at login, and specifies the method used.
			
			This example uses a local authentication database. You could also use a RADIUS server for this. For details, see *Cisco IOS Security Configuration Guide: Securing User Services, Release 2.4T* and *Cisco IOS Security Command Reference*.

Step 3	**aaa authorization** {**network**	**exec**	**commands** *level*	**reverse-access**	**configuration**} {**default**	*list-name*} [*method1* [*method2...*]]
						
						Example:
						`Router(config)# aaa authorization network rtr-remote local`
						`Router(config)#`
							Specifies AAA authorization of all network-related service requests, including PPP, and specifies the method of authorization.
							
							This example uses a local authorization database. You could also use a RADIUS server for this. For details, see *Cisco IOS Security Configuration Guide: Securing User Services, Release 2.4T* and *Cisco IOS Security Command Reference*.

Step 4	**username** *name* {**nopassword**	**password** *password*	**password** *encryption-type encrypted-password*}
			
			Example:
			`Router(config)# username username1 password 0 password1`
			`Router(config)#`
				Establishes a username-based authentication system.
				
				This example implements a username of *username1* with an encrypted password of *password1*.

Configure IPSec Transforms and Protocols

A transform set represents a certain combination of security protocols and algorithms. During IKE negotiation, the peers agree to use a particular transform set for protecting data flow.

During IKE negotiations, the peers search multiple transform sets for a transform that is the same at both peers. When a transform set is found that contains such a transform, it is selected and applied to the protected traffic as a part of both peers' configurations.

To specify the IPSec transform set and protocols, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **crypto ipsec profile** *profile-name*
2. **crypto ipsec transform-set** *transform-set-name*
3. **crypto ipsec security-association lifetime** {**seconds** *seconds* | **kilobytes** *kilobytes*}

DETAILED STEPS

	Command or Action	Purpose

Step 1	**crypto ipsec profile** *profile-name*
	
	Example:
	`Router(config)# crypto ipsec profile pro1`
	`Router(config)#`
		Configures an IPSec profile to apply protection on the tunnel for encryption.

Step 2	**crypto ipsec transform-set** *transform-set-name transform1* [*transform2*] [*transform3*] [*transform4*]
	
	Example:
	`Router(config)# crypto ipsec transform-set vpn1 esp-3des esp-sha-hmac`
	`Router(config)#`
		Defines a transform set—an acceptable combination of IPSec security protocols and algorithms.
		
		See *Cisco IOS Security Command Reference* for detail about the valid transforms and combinations.

Step 3	**crypto ipsec security-association lifetime** {**seconds** *seconds*	**kilobytes** *kilobytes*}
		
		Example:
		`Router(config)# crypto ipsec security-association lifetime seconds 86400`
		`Router(config)#`
			Specifies global lifetime values used when IPSec security associations are negotiated.
			
			See *Cisco IOS Security Command Reference* for details.

Configure the IPSec Crypto Method and Parameters

A dynamic crypto map policy processes negotiation requests for new security associations from remote IPSec peers, even if the router does not know all the crypto map parameters (for example, IP address).

To configure the IPSec crypto method, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **crypto dynamic-map** *dynamic-map-name dynamic-seq-num*
2. **set transform-set** ***transform-set-name*** **[*transform-set-name2...transform-set-name6*]**
3. **reverse-route**
4. **exit**
5. **crypto map** ***map-name seq-num*** **[ipsec-isakmp] [dynamic** ***dynamic-map-name*****] [discover] [profile** ***profile-name*****]**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**crypto dynamic-map** *dynamic-map-name dynamic-seq-num*
	
	Example:
	`Router(config)# crypto dynamic-map dynmap 1`
	`Router(config-crypto-map)#`
		Creates a dynamic crypto map entry and enters crypto map configuration mode.
		
		See *Cisco IOS Security Command Reference* for more detail about this command.

Step 2	**set transform-set** *transform-set-name* [*transform-set-name2...transform-set-name6*]
	
	Example:
	`Router(config-crypto-map)# set transform-set vpn1`
	`Router(config-crypto-map)#`
		Specifies which transform sets can be used with the crypto map entry.

Step 3	**reverse-route**
	
	Example:
	`Router(config-crypto-map)# reverse-route`
	`Router(config-crypto-map)#`
		Creates source proxy information for the crypto map entry.
		
		See *Cisco IOS Security Command Reference* for details.

	Command or Action	Purpose

Step 4	**exit**
	
	Example:
	`Router(config-crypto-map)# exit`
	`Router(config)#`
		Returns to global configuration mode.

Step 5	**crypto map** *map-name seq-num* [**ipsec-isakmp**] [**dynamic** *dynamic-map-name*] [**discover**] [**profile** *profile-name*]
	
	Example:
	`Router(config)# crypto map static-map 1 ipsec-isakmp dynamic dynmap`
	`Router(config)#`
		Creates a crypto map profile.

Apply the Crypto Map to the Physical Interface

The crypto maps must be applied to each interface through which IPSec traffic flows. Applying the crypto map to the physical interface instructs the router to evaluate all the traffic against the security associations database. With the default configurations, the router provides secure connectivity by encrypting the traffic sent between remote sites. However, the public interface still allows the rest of the traffic to pass and provides connectivity to the Internet.

To apply a crypto map to an interface, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **interface** *type number*
2. **crypto map** *map-name*
3. **exit**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**interface** *type number*
	
	Example:
	`Router(config)# interface fastethernet 4`
	`Router(config-if)#`
		Enters the interface configuration mode for the interface to which you are applying the crypto map.

	Command or Action	Purpose

Step 2	**crypto map** *map-name*
	
	Example:
	`Router(config-if)# crypto map static-map`
	`Router(config-if)#`
		Applies the crypto map to the interface.
		
		See *Cisco IOS Security Command Reference* for more detail about this command.

Step 3	**exit**
	
	Example:
	`Router(config-crypto-map)# exit`
	`Router(config)#`
		Returns to global configuration mode.

Where to Go Next

If you are creating a Cisco Easy VPN remote configuration, go to the "Create a Cisco Easy VPN Remote Configuration" section on page 139.

If you are creating a site-to-site VPN using IPSec tunnels and GRE, go to the "Configure a Site-to-Site GRE Tunnel" section on page 142.

Create a Cisco Easy VPN Remote Configuration

The router that is acting as the Cisco Easy VPN client must create a Cisco Easy VPN remote configuration and assign it to the outgoing interface.

To create the remote configuration, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **crypto ipsec client ezvpn** *name*
2. **group** *group-name* **key** *group-key*
3. **peer** {*ipaddress* | *hostname*}
4. **mode {client | network-extension | network extension plus}**
5. **exit**
6. **crypto isakmp keepalive** *seconds*
7. **interface** *type number*
8. **crypto ipsec client ezvpn** *name* **[outside | inside]**
9. **exit**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**crypto ipsec client ezvpn** *name*
	
	Example:
	`Router(config)# crypto ipsec client ezvpn ezvpnclient`
	`Router(config-crypto-ezvpn)#`
		Creates a Cisco Easy VPN remote configuration, and enters Cisco Easy VPN remote configuration mode.

Step 2	**group** *group-name* **key** *group-key*
	
	Example:
	`Router(config-crypto-ezvpn)# group ezvpnclient key secret-password`
	`Router(config-crypto-ezvpn)#`
		Specifies the IPSec group and IPSec key value for the VPN connection.

Step 3	**peer** {*ipaddress* | *hostname*}
	
	Example:
	`Router(config-crypto-ezvpn)# peer 192.168.100.1`
	`Router(config-crypto-ezvpn)#`
		Specifies the peer IP address or hostname for the VPN connection.
		Note A hostname can be specified only when the router has a DNS server available for hostname resolution.
		Note Use this command to configure multiple peers for use as backup. If one peer goes down, the Easy VPN tunnel is established with the second available peer. When the primary peer comes up again, the tunnel is reestablished with the primary peer.

Step 4	**mode** {**client** | **network-extension** | **network extension plus**}
	
	Example:
	`Router(config-crypto-ezvpn)# mode client`
	`Router(config-crypto-ezvpn)#`
		Specifies the VPN mode of operation.

Step 5	**exit**
	
	Example:
	`Router(config-crypto-ezvpn)# exit`
	`Router(config)#`
		Returns to global configuration mode.

Step 6	**crypto isakmp keepalive** *seconds*
	
	Example:
	`Router(config-crypto-ezvpn)# crypto isakmp keepalive 10`
	`Router(config)#`
		Enables dead peer detection messages. Time between messages is given in seconds, with a range of 10 to 3600.

	Command or Action	Purpose

Step 7	**interface** *type number*
	
	Example:
	`Router(config)# interface fastethernet 4`
	`Router(config-if)#`
		Enters the interface configuration mode for the interface to which you are applying the Cisco Easy VPN remote configuration.
		
		Note For routers with an ATM WAN interface, this command would be **interface atm 0**.

Step 8	**crypto ipsec client ezvpn** *name* [**outside** | **inside**]
	
	Example:
	`Router(config-if)# crypto ipsec client ezvpn ezvpnclient outside`
	`Router(config-if)#`
		Assigns the Cisco Easy VPN remote configuration to the WAN interface which causes the router to automatically create the NAT or PAT[1] and the access list configuration needed for the VPN connection.

Step 9	**exit**
	
	Example:
	`Router(config-crypto-ezvpn)# exit`
	`Router(config)#`
		Returns to global configuration mode.

1. PAT = port address translation

Configuration Example

The following configuration example shows a portion of the configuration file for the VPN and IPSec tunnel described in this chapter.

```
!
aaa new-model
!
aaa authentication login rtr-remote local
aaa authorization network rtr-remote local
aaa session-id common
!
username username1 password 0 password1
!
crypto isakmp policy 1
    encryption 3des
    authentication pre-share
    group 2
    lifetime 480
!
crypto isakmp client configuration group rtr-remote
    key secret-password
    dns 10.50.10.1 10.60.10.1
    domain company.com
    pool dynpool
!
crypto ipsec transform-set vpn1 esp-3des esp-sha-hmac
!
crypto ipsec security-association lifetime seconds 86400
!
crypto dynamic-map dynmap 1
    set transform-set vpn1
    reverse-route
!
crypto map static-map 1 ipsec-isakmp dynamic dynmap
crypto map dynmap isakmp authorization list rtr-remote
crypto map dynmap client configuration address respond
```

```
crypto ipsec client ezvpn ezvpnclient
    connect auto
    group 2 key secret-password
    mode client
    peer 192.168.100.1
!

interface fastethernet 4
    crypto ipsec client ezvpn ezvpnclient outside
    crypto map static-map
!
interface vlan 1
    crypto ipsec client ezvpn ezvpnclient inside
!
```

Configure a Site-to-Site GRE Tunnel

To configure a site-to-site GRE tunnel, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **interface** *type number*
2. **ip address** ***ip-address mask***
3. **tunnel source** ***interface-type number***
4. **tunnel destination** ***default-gateway-ip-address***
5. **crypto map** ***map-name***
6. **exit**
7. **ip access-list {standard | extended}** ***access-list-name***
8. **permit** ***protocol source source-wildcard destination destination-wildcard***
9. **exit**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**interface** *type number*
	
	Example:
	`Router(config)# interface tunnel 1`
	`Router(config-if)#`
		Creates a tunnel interface and enters interface configuration mode.

Step 2	**ip address** *ip-address mask*
	
	Example:
	`Router(config-if)# 10.62.1.193`
	`255.255.255.252`
	`Router(config-if)#`
		Assigns an address to the tunnel.

	Command or Action	Purpose

Step 3	**tunnel source** *interface-type number*
	
	Example:
	`Router(config-if)# tunnel source fastethernet 0`
	`Router(config-if)#`
		Specifies the source endpoint of the router for the GRE tunnel.

Step 4	**tunnel destination** *default-gateway-ip-address*
	
	Example:
	`Router(config-if)# tunnel destination 192.168.101.1`
	`Router(config-if)#`
		Specifies the destination endpoint of the router for the GRE tunnel.

Step 5	**crypto map** *map-name*
	
	Example:
	`Router(config-if)# crypto map static-map`
	`Router(config-if)#`
		Assigns a crypto map to the tunnel.
		
		Note Dynamic routing or static routes to the tunnel interface must be configured to establish connectivity between the sites. See *Cisco IOS Security Configuration Guide: Secure Connectivity, Release 12.4T* for details.

Step 6	**exit**
	
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits interface configuration mode and returns to global configuration mode.

Step 7	**ip access-list** {**standard** | **extended**} *access-list-name*
	
	Example:
	`Router(config)# ip access-list extended vpnstatic1`
	`Router(config-acl)#`
		Enters ACL[1] configuration mode for the named ACL that the crypto map uses.

Step 8	**permit** *protocol source source-wildcard destination destination-wildcard*
	
	Example:
	`Router(config-acl)# permit gre host 192.168.100.1 host 192.168.101.1`
	`Router(config-acl)#`
		Specifies that only GRE traffic is permitted on the outbound interface.

Step 9	**exit**
	
	Example:
	`Router(config-acl)# exit`
	`Router(config)#`
		Returns to global configuration mode.

1. ACL = access control list

Configuration Example

The following configuration example shows a portion of the configuration file for a site-to-site VPN using a GRE tunnel as described in the preceding sections.

```
!
aaa new-model
!
aaa authentication login rtr-remote local
aaa authorization network rtr-remote local
aaa session-id common
!
username username1 password 0 password1
!
interface tunnel 1
    ip address 10.62.1.193 255.255.255.252

tunnel source fastethernet 0

tunnel destination interface 192.168.101.1

ip route 20.20.20.0 255.255.255.0 tunnel 1

crypto isakmp policy 1
    encryption 3des
    authentication pre-share
    group 2
!
crypto isakmp client configuration group rtr-remote
    key secret-password
    dns 10.50.10.1 10.60.10.1
    domain company.com
    pool dynpool
!
crypto ipsec transform-set vpn1 esp-3des esp-sha-hmac
!
crypto ipsec security-association lifetime seconds 86400
!
crypto dynamic-map dynmap 1
    set transform-set vpn1
    reverse-route
!
crypto map static-map 1 ipsec-isakmp dynamic dynmap
crypto map dynmap isakmp authorization list rtr-remote
crypto map dynmap client configuration address respond
!
! Defines the key association and authentication for IPsec tunnel.
crypto isakmp policy 1
hash md5
authentication pre-share
crypto isakmp key cisco123 address 200.1.1.1
!
!
! Defines encryption and transform set for the IPsec tunnel.
crypto ipsec transform-set set1 esp-3des esp-md5-hmac
!
! Associates all crypto values and peering address for the IPsec tunnel.
crypto map to_corporate 1 ipsec-isakmp
 set peer 200.1.1.1
 set transform-set set1
 match address 105
!
!
```

```
! VLAN 1 is the internal home network.
interface vlan 1
 ip address 10.1.1.1 255.255.255.0
 ip nat inside
 ip inspect firewall in ! Inspection examines outbound traffic.
    crypto map static-map
    no cdp enable
!
! FE4 is the outside or Internet-exposed interface
interface fastethernet 4
 ip address 210.110.101.21 255.255.255.0
 ! acl 103 permits IPsec traffic from the corp. router as well as
 ! denies Internet-initiated traffic inbound.
 ip access-group 103 in
 ip nat outside
 no cdp enable
 crypto map to_corporate ! Applies the IPsec tunnel to the outside interface.
!
! Utilize NAT overload in order to make best use of the
! single address provided by the ISP.
ip nat inside source list 102 interface Ethernet1 overload
ip classless
ip route 0.0.0.0 0.0.0.0 210.110.101.1
no ip http server
!
!
! acl 102 associated addresses used for NAT.
access-list 102 permit ip 10.1.1.0 0.0.0.255 any
! acl 103 defines traffic allowed from the peer for the IPsec tunnel.
access-list 103 permit udp host 200.1.1.1 any eq isakmp
access-list 103 permit udp host 200.1.1.1 eq isakmp any
access-list 103 permit esp host 200.1.1.1 any
! Allow ICMP for debugging but should be disabled because of security implications.
access-list 103 permit icmp any any
access-list 103 deny ip any any ! Prevents Internet-initiated traffic inbound.
! acl 105 matches addresses for the IPsec tunnel to or from the corporate network.
access-list 105 permit ip 10.1.1.0 0.0.0.255 192.168.0.0 0.0.255.255
no cdp run
```

Configuring Dynamic Multipoint VPN

The Dynamic Multipoint VPN (DMVPN) feature allows users to better scale large and small IP Security (IPsec) VPNs by combining GRE tunnels, IPsec encryption, and Next Hop Resolution Protocol (NHRP).

For additional information about configuring DMVPN, see the "Dynamic Multipoint VPN" section of *Cisco IOS Security Configuration Guide: Secure Connectivity, Release 12.4T* at: http://www.cisco.com/en/US/docs/ios/sec_secure_connectivity/configuration/guide/12_4t/sec_secure_connectivity_12_4t_book.html.

Configuring Group Encrypted Transport VPN

Group Encrypted Transport (GET) VPN is a set of features that are necessary to secure IP multicast group traffic or unicast traffic over a private WAN that originates on or flows through a Cisco IOS device. GET VPN combines the keying protocol Group Domain of Interpretation (GDOI) with IPsec encryption to provide users with an efficient method of securing IP multicast traffic or unicast traffic. GET VPN enables the router to apply encryption to nontunneled (that is, “native”) IP multicast and unicast packets and eliminates the requirement to configure tunnels to protect multicast and unicast traffic.

By removing the need for point-to-point tunnels, meshed networks can scale higher while maintaining network-intelligence features that are critical to voice and video quality, such as QoS, routing, and multicast. GET VPN offers a new standards-based IP security (IPsec) security model that is based on the concept of “trusted” group members. Trusted member routers use a common security methodology that is independent of any point-to-point IPsec tunnel relationship.

For additional information about configuring GET VPN, see *Cisco Group Encrypted Transport VPN* at: http://www.cisco.com/en/US/docs/ios/12_4t/12_4t11/htgetvpn.html.

SGT over Ethernet Tagging

Cisco TrustSec (CTS) is an end-to-end network infrastructure that provides a scalable architecture for enforcement of role-based access control, identity-aware networking, and data confidentiality that helps to secure the network and its resources. CTS works by identifying and authenticating each network user and resource and assigning a 16-bit number called Security Group Tag (SGT). SGT is then propagated between network hops to allow intermediary devices (switches and routers) to enforce policies based on the identity tag.

CTS-capable devices have built-in hardware capabilities than can send and receive packets with SGT embedded in the MAC (L2) layer. This feature is called L2-SGT imposition. This allows Ethernet interfaces on the device to be enabled for L2-SGT imposition to enable the device to insert an SGT in the packet that is to be carried to its next- hop Ethernet neighbor. SGT over Ethernet Tagging is a type of hop-by-hop propagation of SGTs embedded in clear-text (unencrypted) Ethernet packets.

Restrictions for SGT over Ethernet Tagging

- SGT over Ethernet Tagging is supported on plain-text Ethernet frames only.
- SGT over Ethernet Tagging is supported on on-board Gigabit Ethernet interfaces on the following Cisco ISR G2 Series routers:
  - Cisco ISR G2 2951
  - Cisco ISR G2 3945
  - Cisco ISR G2 3900 E Series
  - Cisco ISR G2 1921
  - ISR G2 1941
  - ISR G2 2901
  - ISR G2 2911
  - ISR G2 2921

Configuring SGT over Ethernet Tagging

Perform these steps to configure SGT over Ethernet Tagging.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet** *slot/port*
4. **cts manual**
5. **propagate sgt**
6. **policy static sgt** *tag* **[trusted]**
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router(config)# enable`	Enables the privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router(config)# configure terminal`	Enters the global configuration mode.
Step 3	**interface gigabitethernet** *slot/port* **Example:** `Router(config)# interface gigabitethernet 0/0`	Enters the interface configuration mode.
Step 4	**cts manual** **Example:** `Router(config-if)# cts manual`	Enables the interface for CTS SGT authorization and forwarding, and enters the CTS manual interface configuration mode.
Step 5	**propagate sgt** **Example:** `Router(config-if-cts-manual)# propagate sgt`	Enables L2-SGT imposition for egress traffic on the interface. **Note** If you configure **cts manual** command, CTS SGT propagation is enabled by default. To disable CTS SGT propagation, use **no propagate sgt** command.
Step 6	**policy static sgt** *tag* **[trusted]** **Example:** `Router(config-if-cts-manual)# policy static sgt 77 trusted`	Configures a static SGT ingress policy on the interface and defines the trustworthiness of an SGT received on the interface. **Note** The **trusted** keyword indicates that the interface is trustworthy for CTS. The SGT value received via the ethernet packet on this interface is trusted and will be used by the device for any SGT-aware policy enforcement or for egress tagging. If the **trusted** keyword is not configured, all the ingress traffic is assigned with the static SGT value specified in the configuration.
Step 7	**end** **Example:** `Router(config-if-cts-manual)# end`	Exits the configuration session.

Example: Configuring SGT over Ethernet Tagging

This example shows how to configure SGT over Ethernet tagging with CTS SGT propagation enabled:

```
Router# configure terminal
Router(config)# interface gigabitethernet 0/0
Router(config-if)# cts manual
Router(config-if-cts-manual)# propagate sgt
Router(config-if-cts-manual)# policy static sgt 77 trusted
Router(config-if-cts-manual)# end
Router# show running interface gigabitethernet 0/0
interface gigabitethernet 0/0
    ip address 50.0.0.1 255.255.255.0
    cts manual
        policy static sgt 77 trusted.
    end
```

This example shows how to configure SGT over Ethernet tagging with CTS SGT propagation disabled:

```
Router# configure terminal
Router(config)# interface gigabitethernet 0/0
Router(config-if)# cts manual
Router(config-if-cts-manual)# no propagate sgt
Router(config-if-cts-manual)# policy static sgt 77 trusted
Router(config-if-cts-manual)# end
Router# show running interface gigabitethernet 0/0
interface gigabitethernet 0/0
    ip address 50.0.0.1 255.255.255.0
    cts manual
        no propagate sgt
        policy static sgt 77 trusted.
    end
```

Verifying SGT over Ethernet Tagging

Use the **show cts interface brief** command to display the CTS interface- specific configuration:

```
Router# show cts interface brief
Interface gigabitethernet 0/0
    CTS is enabled, mode:     MANUAL
      Propagate SGT:          Enabled
      Static Ingress SGT Policy:
        Peer SGT:             77
        Peer SGT assignment:  Trusted
```

Use the s**how cts platform interface** *interface-name* **stats detail** command to display platform-specific CTS-related statistics:

```
Router# show cts platform interface gigabitethernet 0/0 stats detail
Interface gigabitethernet 0/0
    L2-SGT Statistics
        Pkts In                    : 31627
        Pkts (policy SGT assigned) : 24
        Pkts Out                   : 6866
        Pkts Drop (malformed packet): 0
        Pkts Drop (invalid SGT)    : 0
```

Configuring Identity Features on Layer 3 Interface

This chapter describes the identify features supported on the Onboard Gigabit Ethernet Layer 3 ports of the Cisco 1921 Integrated Services Router (ISR).

This chapter contains the following sections:

- Authentication Methods, page 151
- Controlling Port Authorization State, page 155
- Flexible Authentication, page 158
- Host mode, page 158
- Open Access, page 158
- Control-Direction (Wake-on-LAN), page 159
- Preauthentication Access Control List, page 162
- Downloadable Access Control List, page 163
- Filter-ID or Named Access Control List, page 163
- IP Device Tracking, page 163

Note Critical authentication, which is also known as Inaccessible Authentication Bypass or AAA Fail Policy, does not support the Identity features on the Onboard Gigabit Ethernet Layer 3 ports.

Authentication Methods

Identity features support various types of authentication methods that are suitable for different kinds of end hosts and users. The two methods that are mainly used are:

- IEEE 802.1X
- MAC Authentication Bypass (MAB)

Configuring the IEEE 802.1X

Perform these steps to configure the IEEE 802.1X on the Cisco 1921 ISR.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet** *slot / port*
4. **authentication port-control auto**
5. **dot1x pae authenticator**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet** *slot/port* **Example:** `Router(config)# interface gigabitethernet 0/0`	Enters interface configuration mode.
Step 4	**authentication port-control auto** **Example:** `Router(config-if)# authentication port-control auto`	Enables the manual control of the port authorization state.
Step 5	**dot1x pae authenticator** **Example:** `Router(config-if)#dot1x pae authenticator`	Configures the port as an IEEE 802.1x Port Access Entity (PAE) authenticator.

Step 6	**end**
	
	Example:
	`Router(config-if)# end`
	`Router#`
		Returns to privileged EXEC mode.

Verifying the IEEE 802.1X

Use the **show authentication sessions** command to verify the configuration:

```
c1921#show authentication sessions
```

```
Interface      MAC Address     Method   Domain   Status         Session ID
Gi0/1          000d.e105.c771  dot1x    DATA     Authz Success  0303030300000000000BA04

c1921#show authentication sessions interface Gi0/1
            Interface:  GigabitEthernet0/1
          MAC Address:  0201.0201.0201
           IP Address:  Unknown
            User-Name:  testUser1
               Status:  Authz Success
               Domain:  DATA
       Oper host mode:  single-host
     Oper control dir:  both
        Authorized By:  Authentication Server
           Vlan Group:  N/A
          AAA Policies:
      Session timeout:  N/A
         Idle timeout:  N/A
    Common Session ID:  0303030300000000000BA04
      Acct Session ID:  0x00000001
               Handle:  0x6D000001

Runnable methods list:
       Method   State
       dot1x    Authc Success

c1921#
```

Configuring the MAC Authentication Bypass (MAB)

Perform these steps to configure the MAB.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet** *slot / port*
4. **authentication port-control auto**
5. **mab**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet** *slot/port* **Example:** `Router(config)# interface gigabitethernet 0/0`	Enters interface configuration mode.
Step 4	**authentication port-control auto** **Example:** `Router(config-if)# authentication port-control auto`	Enables the manual control of the port authorization state.
Step 5	**mab** **Example:** `Router(config-if)# mab`	Enables MAC-based authentication on a port.

Step 6	**end**
	
	Example:
	`Router(config-if)# end`
	`Router#`
		Returns to privileged EXEC mode.

Verifying the MAB

Use the **show authentication sessions** command to verify the configuration:

```
c1921#show authentication sessions

Interface      MAC Address     Method   Domain   Status         Session ID
Gi0/1          0201.0201.0201  mab      DATA     Authz Success  0303030300000004002500A8

c1921#show authentication sessions interface Gi0/1
            Interface:  GigabitEthernet0/1
          MAC Address:  0201.0201.0201
           IP Address:  Unknown
            User-Name:  02-01-02-01-02-01
               Status:  Authz Success
```

```
               Domain:  DATA
        Oper host mode:  single-host
      Oper control dir:  both
         Authorized By:  Authentication Server
           Vlan Group:  N/A
          AAA Policies:
       Session timeout:  N/A
          Idle timeout:  N/A
    Common Session ID:  03030303000000004002500A8
      Acct Session ID:  0x00000007
                Handle:  0x3D000005

Runnable methods list:
       Method   State
       mab      Authc Success

c1921#
```

Controlling Port Authorization State

You can control the port authorization by using the following methods:

- Force-authorized-This is the default setting that disables IEEE 802.1X and causes a port to transition to the authorized state without any authentication exchange required. The port transmits and receives normal traffic without IEEE 802.1X-based authentication of the client.
- Force-unauthorized-This causes a port to remain in the unauthorized state, ignoring all the authentication attempts made by a client. A router cannot provide authentication services to clients through the interface.
- Auto-This enables IEEE 802.1X authentication and causes a port to start in the unauthorized state, allowing only Extensible Authentication Protocol over LAN (EAPoL) frames to be sent and received through a port. The authentication process begins when the link state of the port transitions from down to up, or when an EAPoL-start frame is received. The router requests the identity of the client and begins relaying authentication messages between the client and the authentication server. Each client attempting to access the network is uniquely identified by the router with the help of the client's MAC address. If the client is successfully authenticated, the port state changes to authorized, and all the frames from the authenticated client are allowed through the port. If authentication fails, the port remains in the unauthorized state, but authentication can be retried.

Configuring the Controlling Port Authorization State

Perform these steps to configure the Controlling Port Authorization state.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet** *slot / port*
4. **authentication port-control auto**
5. **mab**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet** *slot/port* **Example:** `Router(config)# interface gigabitethernet 0/0`	Enters interface configuration mode.
Step 4	**authentication port-control** {*auto* | *force-authorized* | *force-unauthorized*} **Example:** `Router(config-if)# authentication port-control {auto | force-authorized | force-unauthorized}`	Enables the manual control of the port authorization state. **auto**-Allows only EAPol traffic until successful authentication. **force-authorized**-Allows all traffic, requires no authentication. **force-unauthorized**-Allows no traffic.
Step 5	**mab** **Example:** `Router(config-if)# mab`	Enables MAC-based authentication on a port.

Step 6	**end**
	
	Example:
	`Router(config-if)# end`
	`Router#`
		Returns to privileged EXEC mode.

Verifying the Controlling Port Authorization State

Use the **show authentication sessions** and **show dot1x** commands to verify the Controlling Port Authorization state:

```
c1921#show authentication sessions

Interface      MAC Address     Method   Domain   Status         Session ID
Gi0/1          (unknown)       dot1x    DATA     Authz Success  030303030000000A002CFCBC

c1921#show authentication sessions interface gi0/1
            Interface:  GigabitEthernet0/1
          MAC Address:  Unknown
           IP Address:  Unknown
```

```
               Status:  Authz Success
               Domain:  DATA
        Oper host mode:  single-host
      Oper control dir:  both
         Authorized By:  Authentication Server
             Vlan Group:  N/A
        Session timeout:  N/A
           Idle timeout:  N/A
     Common Session ID:  030303030000000A002CFCBC
       Acct Session ID:  0x0000000D
               Handle:  0x7C00000B

Runnable methods list:
       Method   State
       dot1x    Authc Success

c1921#show dot1x interface g0/1
Dot1x Info for GigabitEthernet0/1
-----------------------------------
PAE                       = AUTHENTICATOR
PortControl               = FORCE_AUTHORIZED
ControlDirection          = Both
HostMode                  = SINGLE_HOST
QuietPeriod               = 60
ServerTimeout             = 0
SuppTimeout               = 30
ReAuthMax                 = 2
MaxReq                    = 2
TxPeriod                  = 30

c1921#show authentication sessions

Interface      MAC Address     Method   Domain   Status         Session ID
Gi0/1          (unknown)       dot1x    DATA     Authz Failed   0303030300000009002AB7FC

c1921#show authentication sessions interface gi0/1
            Interface:  GigabitEthernet0/1
          MAC Address:  Unknown
           IP Address:  Unknown
               Status:  Authz Failed
               Domain:  DATA
        Oper host mode:  single-host
      Oper control dir:  both
       Session timeout:  N/A
          Idle timeout:  N/A
     Common Session ID:  03030303000000009002AB7FC
       Acct Session ID:  0x0000000C
               Handle:  0x8B00000A

Runnable methods list:
       Method   State
       dot1x    Authc Failed

c1921#show dot1x interface g0/1
Dot1x Info for GigabitEthernet0/1
-----------------------------------
PAE                       = AUTHENTICATOR
PortControl               = FORCE_UNAUTHORIZED
ControlDirection          = Both
HostMode                  = SINGLE_HOST
QuietPeriod               = 60
ServerTimeout             = 0
SuppTimeout               = 30
ReAuthMax                 = 2
```

```
MaxReq                  = 2
TxPeriod                = 30
```

Flexible Authentication

Flexible Authentication sequencing allows a user to enable all or some authentication methods on a router port and specify the order in which the methods should be executed.

Configuring Flexible Authentication

For more information about configuring of Flexible Authentication, see:

http://www.cisco.com/c/en/us/products/collateral/ios-nx-os-software/identity-based-networking-service/application_note_c27-573287.html

Host mode

Only single-host mode is supported for the Identity features on the Onboard Gigabit Ethernet Layer 3 ports. In single-host mode, only one client can be connected to the IEEE 802.1X-enabled router port. The router detects the client by sending an EAPol frame when the port link state changes to up state. If a client leaves or is replaced with another client, the router changes the port link state to down, and the port returns to the unauthorized state.

Open Access

The Open Access feature allows clients or devices to gain network access before authentication is performed. This is primarily required for the Preboot eXecution Environment (PXE) scenario where a device is required to access the network before PXE times out and downloads a bootable image, which contains a supplicant.

Configuring Open Access

Perform these steps to configure Open Access.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet** *slot / port*
4. **authentication open**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet** *slot/port* **Example:** `Router(config)# interface gigabitethernet 0/0`	Enters interface configuration mode.
Step 4	**authentication open** **Example:** `Router(config-if)# authentication open`	Enables open access on a port.

Step 5	**end**
	
	Example:
	`Router(config-if)# end`
	`Router#`
		Returns to privileged EXEC mode.

Control-Direction (Wake-on-LAN)

When the router uses IEEE 802.1X authentication with Wake-on-LAN (WoL), the router forwards traffic to the unauthorized IEEE 802.1X ports, including the magic packets. While the port is unauthorized, the switch continues to block ingress traffic other than EAPol packets. The host can receive packets, but cannot send packets to other devices in the network.

Configuring Control-Direction (Wake-on-LAN)

Perform these steps to configure Control-Direction (Wake-on-LAN).

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet** *slot / port*
4. **authentication control-direction {in|both}**

5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet** *slot/port* **Example:** `Router(config)# interface gigabitethernet 0/0`	Enters interface configuration mode.

Step 4	**authentication control-direction {*in*|*both*}**
	
	Example:
	`Router(config-if)# authentication control-direction in`
	`Router(config-if)# authentication control-direction both`
		Configures the port mode as unidirectional or bidirectional.
		in-The port can send packets to the host, but cannot receive packets from the host.
		both-The port cannot receive packets from or send packets to the host. This is the default value.

Step 5	**end**
	
	Example:
	`Router(config-if)# end`
	`Router#`
		Returns to privileged EXEC mode.

Verifying Default Control-Direction Setting-Both

Use the **show authentication sessions** and **show dot1x** commands to verify the default control-direction setting-both:

```
c1921#show authentication sessions interface Gi0/1
            Interface:  GigabitEthernet0/1
          MAC Address:  0201.0201.0201
           IP Address:  Unknown
            User-Name:  testUser1
               Status:  Authz Success
               Domain:  DATA
      Oper host mode:  single-host
    Oper control dir:  both
       Authorized By:  Authentication Server
          Vlan Group:  N/A
         AAA Policies:
     Session timeout:  N/A
        Idle timeout:  N/A
   Common Session ID:  0303030300000000000BA04
     Acct Session ID:  0x00000001
              Handle:  0x6D000001

Runnable methods list:
       Method   State
       dot1x    Authc Success

c1921#

c1921#sh dot1x int g0/1
Dot1x Info for GigabitEthernet0/1
-----------------------------------
PAE                       = AUTHENTICATOR
PortControl               = AUTO
ControlDirection          = Both
HostMode                  = SINGLE_HOST
QuietPeriod               = 60
ServerTimeout             = 0
SuppTimeout               = 30
ReAuthMax                 = 2
MaxReq                    = 2
TxPeriod                  = 30
```

Verifying Authentication Control-Direction Setting-in

Use the **show authentication sessions** and **show dot1x** commands to verify the authentication control-direction setting-in:

```
c1921#show authentication sessions interface gi0/1
            Interface:  GigabitEthernet0/1
          MAC Address:  0201.0201.0201
           IP Address:  Unknown
            User-Name:  testUser1
               Status:  Authz Success
               Domain:  DATA
      Oper host mode:  single-host
     Oper control dir:  in
        Authorized By:  Authentication Server
          Vlan Group:  N/A
         AAA Policies:
      Session timeout:  N/A
         Idle timeout:  N/A
    Common Session ID:  030303030000000C00310024
      Acct Session ID:  0x0000000F
               Handle:  0x8C00000D

Runnable methods list:
       Method   State
       dot1x    Authc Success

c1921#show dot1x interface g0/1
Dot1x Info for GigabitEthernet0/1
-----------------------------------
PAE                       = AUTHENTICATOR
PortControl               = AUTO
ControlDirection          = In
HostMode                  = SINGLE_HOST
QuietPeriod               = 60
ServerTimeout             = 0
SuppTimeout               = 30
ReAuthMax                 = 2
MaxReq                    = 2
TxPeriod                  = 30
```

Preauthentication Access Control List

When Open-Access is installed, we recommend that a default port access control list (ACL) is configured on the authenticator. The ACL allows the end point to get a minimum access to the network to get its IP Address and running.

Configuring the Preauthentication Access Control List

For information about preconfiguring ACL, see:

http://www.cisco.com/c/en/us/td/docs/switches/lan/catalyst6500/ios/12-2SY/configuration/guide/sy_swcg/port_acls.html#wp1039754

Downloadable Access Control List

A Downloadable ACL is also referred to as dACL. For a dACL to work on a port, the ip device tracking feature should be enabled and the end point connected to the port should have an IP address assigned. After authentication on the port, use the **show ip access-list privileged EXEC** command to display the downloaded ACL on the port.

Filter-ID or Named Access Control List

Filter-Id also works as a dACL, but the ACL commands are configured on the authenticator. Authentication, authorization, and accounting (AAA) provides the name of the ACL to the authenticator.

IP Device Tracking

The IP Device Tracking feature is required for the dACL and Filter-ID features to function. To program a dACL or Filter-ID in a device, IP address is required. IP device tracking provides the IP address of the corresponding device to the Enterprise Policy Manager (EPM) module to convert the dACLs to each user by adding the IP address to them.

Unified Communications on Cisco Integrated Services Routers

The following sections describe Unified Communications (UC) application services that are supported on Cisco 3900 series and Cisco 2900 series integrated services routers (ISRs).

- Modules and Interface Cards, page 166
- Call Control, page 166
  - Cisco Unified Communications Manager Express, page 166
  - Unified Survivable Remote Site Telephony, page 167
  - Cisco Unified SIP Proxy (CUSP), page 168
  - Gatekeeper, page 168
- Call Control Protocols, page 168
  - Trunk-side Protocols, page 168
  - Line-side Protocols, page 169
- Unified Communications Gateways, page 170
  - TDM Gateways, page 171
  - Cisco Unified Border Element, page 172
  - Unified Messaging Gateway, page 172
- IP Media Services, page 173
  - Conferencing, Transcoding and Media Termination Point (MTP), page 173
  - RSVP Agent, page 173
  - Trusted Relay Point (TRP), page 173
  - Packet Voice Data Module, page 174
- Voice Security, page 174
  - UC Trusted Firewall, page 174
  - Signaling and Media Authentication and Encryption, page 175
  - Virtual Route Forward, page 175
- Applications and Application Interfaces (APIs), page 175
  - Cisco Unity Express, page 176
  - Voice XML, page 176

– Hoot-n-Holler, page 177
– Cisco Application Extension Platform, page 177
– APIs, page 177
• Online Insertion and Removal, page 178

Modules and Interface Cards

Cisco 3900 series and Cisco 2900 series ISRs support Unified Communications (UC) modules and interface cards in the following slots:

- Next-generation packet voice/data module (PVDM3)
- Service module (SM)
- Enhanced high-speed WAN interface card (EHWIC)

Note The PVDM3 slot and the SM slot are not backwards compatible with legacy modules. Legacy modules require an adapter for installation in these slots.

For a list of supported UC modules and interface cards see *Module Support on Cisco Integrated Services Routers Generation 2*.

Call Control

The Cisco 3900 series and Cisco 2900 series ISRs support the following types of call control applications and Cisco Voice solutions:

- Cisco Unified Communications Manager Express, page 166
- Unified Survivable Remote Site Telephony, page 167
- Cisco Unified SIP Proxy (CUSP), page 168
- Gatekeeper, page 168

Cisco Unified Communications Manager Express

Cisco Unified Communications Manager Express (CME) is a feature-rich entry-level IP telephony solution that is integrated directly into Cisco IOS software. Cisco Unified CME allows small business customers and autonomous small enterprise branch offices to deploy voice, data, and IP telephony on a single platform for small offices, thereby streamlining operations and lowering network costs.

Cisco Unified CME is ideal for customers who have data connectivity requirements and also have a need for a telephony solution in the same office. Whether offered through a service provider's managed services offering or purchased directly by a corporation, Cisco Unified CME offers most of the core telephony features required in the small office, and also many advanced features not available with traditional telephony solutions. The ability to deliver IP telephony and data routing by using a single converged solution allows customers to optimize their operations and maintenance costs, resulting in a very cost-effective solution that meets office needs.

A Cisco Unified CME system is extremely flexible because it is modular. A Cisco Unified CME system consists of a router that serves as a gateway and one or more VLANs that connect IP phones and phone devices to the router.

See Cisco Unified Communications Manager Express (CME) Overview at: http://www.cisco.com/en/US/docs/voice_ip_comm/cucme/admin/configuration/guide/cmeover.html.

Unified Survivable Remote Site Telephony

Cisco Unified Survivable Remote Site Telephony (SRST) enables Cisco routers to provide call-handling support for Cisco IP phones when they lose connection to Cisco Unified Communications Manager (CUCM) installations, or when the WAN connection is down. In a centralized deployment, under normal conditions, Cisco IP phones are controlled by the Cisco Unified Communications Manager located at a central site like the headquarters of an enterprise. When connection to CUCM breaks, for example as result of a failure in the network, Unified SRST automatically detects the failure and auto configures the router for providing backup call processing functionality.

During a WAN failure, the router allows all the phones to re-register to the remote site router in SRST mode, allowing all inbound and outbound dialing to be routed off to the PSTN (on a backup Foreign Exchange Office (FXO), BRI or Primary Rate Interface (PRI) connection).

Unified SRST provides redundancy for both Cisco IP as well as Analog phones to ensure that the telephone system remains operational during network failures. Both Skinny Client Control Protocol (SCCP) and session initiation protocol (SIP) based Cisco IP phones are supported with the Unified SRST.

When the WAN link or connection to the Cisco Unified Communications Manager is restored, call handling reverts back to the Cisco Unified Communications Manager automatically without need for any human intervention.

For general Unified SRST information, see *Cisco Unified SRST System Administrator Guide*.

- For information on how the H.323 and Media Gateway Control Protocol (MGCP) call control protocols relate to SRST, see *Cisco Unified SRST System Administrator Guide:*
  - For H.323, see *H.323 Gateways and SRST* at Cisco.com.
  - For MGCP, see *MGCP Gateways and SRST* at Cisco.com.
- Configurations of major SRST features are provided in the following chapters of the *Cisco Unified SRST System Administrator Guide*:
  - “Setting up the Network”
  - “Setting up Cisco Unified IP Phones”
  - “Setting up Call Handling”
  - “Configuring Additional Call Features”
  - “Setting up Secure SRST”
  - “Integrating Voice Mail with Cisco Unified SRST”

For SIP-specific SRST information, see *Cisco Unified SIP SRST System Administrator Guide*. To configure SIP SRST features, see the *Cisco Unified SIP SRST 4.1* chapter.

Cisco Unified SIP Proxy (CUSP)

The Cisco Unified SIP Proxy (CUSP) is a high-performance, highly available Session Initiation Protocol (SIP) server for centralized routing and SIP signaling normalization. By forwarding requests between call-control domains, the Cisco Unified SIP Proxy provides the means for routing sessions within enterprise and service provider networks.

To configure CUSP features, see *Configuring Cisco Unified SIP Proxy Version 1.1.3 for an Enterprise Network* at:
http://www.cisco.com/en/US/docs/voice_ip_comm/cusp/rel1_1_3/configuration/guide/cuspgd113.html

Gatekeeper

An H.323 Gatekeeper is an optional node in an H.323 network that manages endpoints (such as H.323 terminals, gateways, and Multipoint Control Units (MCUs), as well as Cisco Unified Communications Manager Express and Cisco Unified Communications Manager clusters). An H.323 Gatekeeper provides these endpoints with call routing and call admission control functions. The endpoints communicate with the Gatekeeper using the H.323 Registration Admission Status (RAS) protocol.

The H.323 Gatekeeper is a special Cisco IOS software image that runs on the Cisco ISR platforms and the AS5350XM and AS5400XM Universal Gateway platforms. The Cisco IOS H.323 Gatekeeper is an application that acts as the point of control for a variety of voice and video components that can be attached to an IP network such as IP telephony devices, IP-PSTN gateways, H.323 video conferencing endpoints, and H.323 multipoint control units while facilitating buildout of large-scale multimedia service networks.

To configure Gatekeeper features, see *Configuring H.323 Gatekeepers and Proxies* at:
http://www.cisco.com/en/US/docs/ios/12_3/vvf_c/cisco_ios_h323_configuration_guide/old_archives_h323/5gkconf.html.

Call Control Protocols

The Cisco 3900 series and Cisco 2900 series ISRs support the following type of call control protocols:

- Trunk-side Protocols, page 168
- Line-side Protocols, page 169

Trunk-side Protocols

The Cisco 3900 series and Cisco 2900 series ISRs support the following trunk-side call control protocols:

- Session Initiation Protocol (SIP), page 169
- Media Gateway Control Protocol (MGCP), page 169
- H.323, page 169

Session Initiation Protocol (SIP)

Session Initiation Protocol (SIP) is a peer-to-peer, multimedia signaling protocol developed in the IETF (IETF RFC 3261). Session Initiation Protocol is ASCII-based. It resembles HTTP, and it reuses existing IP protocols (such as DNS and SDP) to provide media setup and tear down. See *Cisco IOS SIP Configuration Guide* for more information.

For router configuration information under SIP, see *Basic SIP Configuration* chapter of the *Cisco IOS SIP Configuration Guide*.

Voice gateways provide voice security through SIP enhancements within the Cisco IOS Firewall. SIP inspect functionality (SIP packet inspection and detection of pin-hole openings) is provided, as well as protocol conformance and application security. The user is given more granular control on the policies and security checks applied to SIP traffic, and capability to filter out unwanted messages. For more information, see "Cisco IOS Firewall: SIP Enhancements: ALG and AIC" at Cisco.com.

Media Gateway Control Protocol (MGCP)

Media Gateway Control Protocol (MGCP) RFC 2705 defines a centralized architecture for creating multimedia applications, including Voice over IP (VoIP). See *Cisco IOS MGCP and Related Protocols Configuration Guide* for more information.

ISRs are configured primarily as residential gateways (RGWs) under MGCP. For residential gateway configuration information, see the *Configuring an RGW* section of the *Basic MGCP Configuration* chapter of *Cisco IOS MGCP and Related Protocols Configuration Guide*.

H.323

H.323 is an umbrella recommendation from the International Telecommunication Union (ITU) that defines the protocols to provide voice and video communication sessions on a packet network. The H.323 standard addresses call signaling and control, multimedia transport and control, and bandwidth control for point-to-point and multi-point sessions. See *Cisco IOS H.323 Configuration Guide* for more information about H.323.

For router configuration information, see the *Configuring H.323 Gateways* chapter of *Cisco IOS H.323 Configuration Guide*.

Line-side Protocols

The Cisco 3900 series and Cisco 2900 series ISRs support the following line-side call control protocols:

- SCCP-Controlled Analog Ports with Supplementary Features, page 170
- Session Initiation Protocol (SIP), page 170

SCCP-Controlled Analog Ports with Supplementary Features

Voice gateway ISRs support the Cisco Skinny Client Control Protocol (SCCP), which supplies basic and supplementary features on analog voice ports that are controlled by Cisco Unified Communications Manager or by a Cisco Unified Communications Manager Express system. Supported features include:

- Audible message waiting indication
- Call forwarding options
- Call park/pickup options
- Call transfer
- Call waiting
- Caller ID
- 3-party conference calls
- Redial
- Speed dial options

For more information on the features supported and their configuration, see *SCCP Controlled Analog (FXS) Ports with Supplementary Features in Cisco IOS Gateways* at Cisco.com.

Session Initiation Protocol (SIP)

Session Initiation Protocol (SIP) is a peer-to-peer, multimedia signaling protocol developed in the IETF (IETF RFC 3261). Session Initiation Protocol is ASCII-based. It resembles HTTP, and it reuses existing IP protocols (such as DNS and SDP) to provide media setup and tear down. See *Cisco IOS SIP Configuration Guide* for more information.

For router configuration information under SIP, see the *Basic SIP Configuration* chapter of *Cisco IOS SIP Configuration Guide*.

Voice gateways provide voice security through SIP enhancements within the Cisco IOS Firewall. SIP inspect functionality (SIP packet inspection and detection of pin-hole openings) is provided, as well as protocol conformance and application security. The user is given more granular control on the policies and security checks applied to SIP traffic, and capability to filter out unwanted messages. For more information, see "Cisco IOS Firewall: SIP Enhancements: ALG and AIC" at Cisco.com.

Unified Communications Gateways

The Cisco 3900 series and Cisco 2900 series ISRs support the following Unified Communication gateways:

- TDM Gateways, page 171
- Cisco Unified Border Element, page 172
- Unified Messaging Gateway, page 172

TDM Gateways

The Cisco 3900 series and Cisco 2900 series ISRs support the following type of time-division multiplexing (TDM) gateways:

- Voice Gateways, page 171
- Video Gateway, page 171

Voice Gateways

Cisco IOS voice gateways connect TDM equipment such as private branch exchanges (PBXs) and the PSTN to VoIP packet networks. The Cisco ISR voice gateway routers support the widest range of packet telephony-based voice interfaces and signaling protocols within the industry, providing connectivity support for more than 90 percent of all PBXs and public-switched-telephone-network (PSTN) connection points. Signaling support includes T1/E1 Primary Rate Interface (PRI), T1 channel associated signaling (CAS), E1-R2, T1/E1 QSIG protocol, T1 Feature Group D (FGD), Basic Rate Interface (BRI), foreign exchange office (FXO), ear and mouth (E&M), and foreign exchange station (FXS). These voice gateway are highly scalable from just a few analog connections to up to 24 T1 or E1 interfaces.

The Cisco ISR series voice gateway routers can communicate with the Cisco Unified Communications Manager using Session Initiation Protocol (SIP), H.323, or Media Gateway Control Protocol (MGCP). The Cisco IOS voice gateway routers can also connect directly to other Cisco voice gateway routers using SIP or H.323 and to various other VoIP destinations and call agents.

For more information, see *ISDN Voice, Video and Data Call Switching with Router TDM Switching Features* at:
http://www.cisco.com/en/US/tech/tk652/tk653/technologies_tech_note09186a00804794c6.shtml.

For details about tuning voice ports, see *Cisco IOS Voice Port Configuration Guide, Release 12.4T* at Cisco.com at:
http://www.cisco.com/en/US/docs/ios/voice/voiceport/configuration/guide/12_4t/vp_12_4t_book.html.

Video Gateway

The Integrated Data, Voice, and Video Services for ISDN Interfaces feature allows multimedia communications between H.320 endpoints and H.323, SIP, or Skinny Client Control Protocol (SCCP) endpoints.

See *Integrating Data, Voice, and Video Services for ISDN Interfaces* at Cisco.com for details about setting up a Video gateway (http://www.cisco.com/en/US/docs/ios/12_4t/12_4t11/h320gw.html.)

See *Cisco IOS H.323 Configuration Guide, Release 12.4T* at Cisco.com for details about the H.323 protocol (http://www.cisco.com/en/US/docs/ios/voice/h323/configuration/guide/12_4t/vh_12_4t_book.html).

Cisco Unified Border Element

Cisco Unified Border Element (Cisco UBE) is a session border controller that provides the necessary services for interconnecting independent Unified Communications networks securely, flexibly, and reliably. Media packets can flow either through the gateway (thus hiding the networks from each other) or around the border element, if so configured. The Cisco UBE is typically used to connect enterprise networks to service provider SIP trunks, or to interconnect different nodes in an enterprise network where protocol or feature incompatibilities exist, or where extra secure demarcation between segments of the network is needed.

The Cisco Unified Border Element provides the following network-to-network interconnect capabilities:

- Session Management: Real-time session setup and tear-down services, call admission control, ensuring QoS, routing of calls if an error occurs, statistics, and billing.
- Interworking: H.323 and SIP protocol conversion; SIP normalization; DTMF conversion, transcoding, codec filtering
- Demarcation: Point of fault isolation, topology hiding, establishing and maintaining network borders, gathering statistics, and billing information on each network segment separately
- Security: Provides interworking between encrypted and non-encrypted network segment, SIP registration services, DOS protection, authentication services, and toll fraud protection on H.323 or SIP trunks.

See *Cisco Unified Border Element Configuration Guide* at Cisco.com for more information, http://www.cisco.com/en/US/docs/ios/voice/cube/configuration/guide/vb_book/vb_book.html.

Unified Messaging Gateway

The Cisco Unified Messaging Gateway provides an open and secure method of intelligently routing messages and exchanging subscriber and directory information within a unified messaging network. It acts as the central hub in a network of Cisco unified messaging solutions and third-party gateways that interface with older voicemail systems.

Unified Messaging Gateway is ideal for companies that need the following key features:

- Scales the unified messaging network as required for branch-office customers and larger distributed enterprises
- Simplifies configuration tasks and centralize voicemail system management
- Transparently integrates Cisco Unified Communications solutions into existing voicemail installations
- Integrates small to large-scale unified messaging deployments that consist of more than five Cisco Unity Express systems.
- Integrates up to 10,000 mixed Cisco Unity Express, Cisco Unity, and Cisco Unity Connection systems.

See *Cisco Unified Messaging Gateway 1.0 Command Reference* at Cisco.com for more information, http://www.cisco.com/en/US/docs/voice_ip_comm/umg/rel1_0/command/reference/UMG_1.0_CmdRef.html.

IP Media Services

The Cisco 3900 series and Cisco 2900 series ISRs support the following media services:

- Conferencing, Transcoding and Media Termination Point (MTP), page 173
- RSVP Agent, page 173
- Trusted Relay Point (TRP), page 173

Conferencing, Transcoding and Media Termination Point (MTP)

Cisco Enhanced Conferencing and Transcoding for Voice Gateway Routers provides conferencing and transcoding capabilities in Cisco IOS Software-based gateways using the onboard Cisco Packet Voice/Fax Digital Signal Processor Modules on the Cisco voice gateway routers. This capability is also supported on Cisco voice gateway router platforms using the Cisco IP Communications Voice/Fax Network Module and the Cisco IP Communications High-Density Digital Voice/Fax Network Module. This feature is delivered in Cisco IOS Software and operates in conjunction with Cisco CallManager.

See *Configuring Enhanced Conferencing and Transcoding for Voice Gateway Routers* at Cisco.com for configuration information, http://www.cisco.com/en/US/docs/ios/12_3/vvf_c/interop/intcnf2.html.

RSVP Agent

The RSVP Agent feature implements a Resource Reservation Protocol (RSVP) agent on Cisco IOS voice gateways that support Cisco Unified Communications Manager Version 5.0.1. The RSVP agent enables Cisco Unified Communications Manager to provide resource reservation for voice and video media to ensure QoS and call admission control (CAC). Cisco Unified Communications Manager controls the RSVP agent through Skinny Client Control Protocol (SCCP). This signaling is independent of the signaling protocol used for the call so SCCP, SIP, H.323, and MGCP calls can all use the RSVP agent.

Benefits of this feature include the following:

- Improves flexibility and scalability of bandwidth management in a meshed network by decentralizing call admission control
- Provides method of managing unpredictable bandwidth requirements of video media
- Enables RSVP across WAN for Cisco IP phones and other devices that do not support RSVP

See *Configuring the RSVP Agent* at Cisco.com for information, http://www.cisco.com/en/US/docs/ios/12_3/vvf_c/interop/int_rsvp.html.

Trusted Relay Point (TRP)

The Cisco Unified Communications system can be deployed in a network virtualization environment. Cisco Unified Communications Manager enables the insertion of trusted relay points (TRPs). The insertion of TRPs into the media path constitutes a first step toward VoIP deployment within a virtual network.

See *Media Resource Management* at Cisco.com for more information, http://www.cisco.com/en/US/docs/voice_ip_comm/cucm/admin/7_0_1/ccmsys/a05media.html#wp1056492.

Packet Voice Data Module

The Next-Generation Packet Voice Data Module (PVDM3) digital signal processor (DSP) modules provide up to four times the density (per slot) of existing audio applications on Cisco voice gateway routers. One universal DSP image for these DSP modules provides resources for time-division multiplexing-to-Internet Protocol (TDM-to-IP) gateway functionality for digital and analog interfaces, audio transcoding, and audio conferencing.

This enhanced DSP architecture accommodates a new packet-processing engine for rich-media voice applications and supports the TDM voice framework used by the PVDM2 module. The PDVM3 has a Gigabit Ethernet interface with a Multi-Gigabit Fabric to increase IP throughput, and a DSP hardware-based health monitor provides DSP failure detection that is ten times faster than existing technology.

To configure PVDM3 features, see the "Configuring Next-Generation High-Density PVDM3 Modules" section on page 181.

Voice Security

The Cisco 3900 series and Cisco 2900 series ISRs support the following voice security services:

- UC Trusted Firewall, page 174
- Signaling and Media Authentication and Encryption, page 175
- Virtual Route Forward, page 175

UC Trusted Firewall

Cisco Unified Communications Trusted Firewall Control pushes intelligent services onto the network through a Trusted Relay Point (TRP). Firewall traversal is accomplished using Simple Session Traversal Utilities for NAT (STUN) on a TRP co-located with a Cisco Unified Communications Manager Express (Cisco Unified CME), Cisco Unified Border Element (CUBE), Media Termination Point (MTP), Transcoder, or Conference Bridge.

Firewall traversal for Unified Communications is often a difficult problem. Voice over IP (VoIP) protocols use many ports for a single communication session and most of these ports (those used for media, H.245 and so forth) are ephemeral. It is not possible to configure static rules for such ports, as they fall in a large range. Cisco Unified Trusted Firewall opens ports dynamically based on the conversation of trusted end-points.

By using UC Trusted Firewall in the network, following things can be achieved:

- Firewall can be made independent of protocol, because only TRP, which is controlled by Call Control needs to be enhanced for various protocols. Firewall does not need to change.
- Increase firewall performance while opening firewall ports in the media path dynamically when a VoIP call is made between two endpoints.
- Simplify the firewall policy configuration and integration of firewall policy generation with call control.
- Provide a solution without compromising on network security.

To configure UC Trusted Firewall features, see *Cisco Unified Communications Trusted Firewall Control* at:
http://www.cisco.com/en/US/docs/voice_ip_comm/cucme/feature/guide/TrustedFirewallControll.html.

Signaling and Media Authentication and Encryption

The Media and Signaling Authentication and Encryption Feature for Cisco IOS MGCP Gateways feature provides support for Cisco Secure Survivable Remote Site Telephony (SRST) and voice security features that include authentication, integrity, and encryption of voice media and related call control signaling.

See *Media and Signaling Authentication and Encryption Feature on Cisco IOS MGCP Gateways* at Cisco.com for configuration information, http://www.cisco.com/en/US/docs/ios/12_3t/12_3t11/feature/guide/gtsecure.html.

The Media and Signaling Encryption (SRTP/TLS) on DSP Farm Conferencing feature provides secure conferencing capability for Cisco Unified Communications Manager (Unified CM) networks, including authentication, integrity and encryption of voice media and related call control signaling to and from the digital signal processor (DSP) farm.

See *Media and Signaling Encryption (SRTP/TLS) on DSP Conferencing Farm* at Cisco.com for configuration information, http://www.cisco.com/en/US/docs/ios/12_4t/12_4t15/itsdsp.html.

See *SIP: SIP Support for SRTP* at Cisco.com for configuration information, http://www.cisco.com/en/US/docs/ios/12_4t/12_4t15/srtpstub.html#wp1008975.

Virtual Route Forward

Virtual Route Forward (VRF) is the technique to create multiple virtual networks within a single network entity. In a single network component, we can create multiple VRFs to create the isolation among each other. In our regular deployment of Unified Communication, we create different VLANs for voice and data to separate traffics. This is Layer-2 virtualization. In conjunction with VAN support, Cisco UC also supports Layer-3 virtualization through VRF for both voice and data.

In a typical UC deployment, hard phones are typically in Voice Segments and PCs are in Data Segments. PCs are inherently un-trusted devices in the network. Mechanisms based on's rely on port numbers and there is no way to ensure only 'trusted' media enters UC Segment. VRF implementations in ISR can create single voice network and multiple data networks, which consolidate voice communication into one logically partitioned network to separate voice and data communication on a converged multi-media network.

To configure Virtual Route Forward features, see *Virtual Route Forwarding Design Guide* at: http://www.cisco.com/en/US/docs/voice_ip_comm/cucme/vrf/design/guide/vrfDesignGuide.html.

Applications and Application Interfaces (APIs)

The Cisco 3900 series and Cisco 2900 series ISRs support the following applications and application interfaces:

- Cisco Unity Express, page 176
- Voice XML, page 176
- Hoot-n-Holler, page 177
- Hoot-n-Holler, page 177
- Cisco Application Extension Platform, page 177
- APIs, page 177

Cisco Unity Express

Cisco Unity Express provides integrated messaging, voicemail, Automated Attendant services, and optional interactive voice response (IVR) for the small and medium-sized office or branch office. The application is delivered on either a network module or advanced integration module, both of which are supported on a variety of voice-enabled integrated services routers.

This application is ideal for companies that need the following:

- Integrated messaging, voicemail, Automated Attendant, or interactive-voice-response (IVR) services at the branch or small office to support local users
- Up to 250 users per site
- Networking of multiple Cisco Unity Express systems for easy management of messages across sites

The application features follow:

- Affordable messaging, greeting services for increased customer service, and rich employee communications.
- Intuitive telephone prompts and a web-based interface provide fast, convenient voicemail, and Automated Attendant administration.
- Cisco Unity Express can view, sort, search, and play back voice messages using the display of a Cisco Unified IP Phone or your e-mail client.
- Scalable solution from 4 to 16 concurrent voicemail or Automated Attendant calls and 12 to 250 mailboxes.
- Deployable with Cisco Unified Communications Manager Express, Cisco Unified Communications Manager, Cisco Unity, and Cisco Unity Connection systems.

See the Unity Express Configuration guides at Cisco.com for more information, http://www.cisco.com/en/US/products/sw/voicesw/ps2237/products_installation_and_configuration_guides_list.html.

Voice XML

Cisco IOS unified communications routers provide many rich voice capabilities, including Voice Extensible Markup Language (VoiceXML) browser services. VoiceXML is an open-standard markup language used to create voice-enabled Web browsers and interactive-voice-response (IVR) applications. Available on a wide range of Cisco IOS Software voice gateways, these services are used in conjunction with a VoiceXML application service such as Cisco Unified Customer Voice Portal (CVP). Other VoiceXML applications can also use the Cisco IOS routers as a VoiceXML browser to provide IVR services to callers.

To configure a Voice XML gateway on the Cisco 3900 series or Cisco 2900 series Integrated Services Router see:
http://www.cisco.com/en/US/docs/ios/voice/ivr/configuration/guide/ivrapp01.html#wp1010676.

Cisco IOS voice features having to do with Cisco IOS Tcl IVR and VoiceXML for developers and network administrators who are installing, configuring, and maintaining a Tcl or VoiceXML application on a Cisco voice gateway are provided at:

http://www.cisco.com/en/US/docs/ios/voice/ivr/configuration/guide/Roadmap.html#wp1008602.

Hoot-n-Holler

Cisco Hoot-n-Holler network solution uses Cisco IOS Multicast and Cisco IOS Voice-over-IP technologies. The Cisco IP-based Hoot network uses bandwidth when it is in use; when it is not, the same bandwidth can be used to carry other traffic. The IP backbone interoperates with existing Hoot & Holler end-station equipment, such as microphones, turrets, Hoot phones, or squawk boxes, as well as bridges and mixers, for a seamless transition. Brokerage houses can adapt this solution to eliminate costly private telco circuits and reap significant operational cost savings—up to millions of dollars per year—for a rapid return on investment.

See *Cisco Hoot and Holler over IP* at Cisco.com for information,
http://www.cisco.com/en/US/docs/ios/12_2/voice/configuration/guide/vvfhhip.html

See *Cisco IOS Multicast for Hoot & Holler Networks* at Cisco.com for information,
http://www.cisco.com/en/US/netsol/ns340/ns394/ns165/ns70/networking_solutions_white_paper09186a00800a3e6c.shtml

Cisco Application Extension Platform

Cisco Application Extension Platform (AXP) is an open network platform for application development, integration and hosting. It is a service module on the Cisco Integrated Services Router (ISR). AXP realizes the "Network as a Platform" vision of Cisco while bringing collaborative partnerships and accelerating innovation. Cisco AXP offers the following features:

- Linux-based integration environment to develop applications that run on routers.
- Certified libraries to implement C, Python, Perl, and Java applications (http web server and SSH are also supported).
- Service APIs for integrating applications into the network.
- Multiple applications can run in their own virtual instance with the ability to segment and guarantee CPU, memory, and disk resources.

See *Cisco Application eXtension Platform Quick Start Guide* at Cisco.com for Getting Started information,
http://www.cisco.com/en/US/docs/interfaces_modules/services_modules/ax/1.0/quick/guide/axpqs.html.

See *Cisco Application eXtension Platform Developer Guide* at Cisco.com for developers information,
http://www.cisco.com/en/US/docs/interfaces_modules/services_modules/ax/1.0/developer/guide/axpdev.html.

APIs

The Cisco 3900 series and Cisco 2900 series ISRs support the following application interfaces:

- TAPI, page 178
- AXL, page 178
- Gatekeeper Transaction Message Protocol (GKTMP), page 178

TAPI

The standard Cisco Unified TAPI provides an unchanging programming interface for different implementations. The goal of Cisco in implementing TAPI for the Cisco Unified Communications Manager platform remains to conform as closely as possible to the TAPI specification, while providing extensions that enhance TAPI and expose the advanced features of Cisco Unified Communications Manager to applications.

See *Basic TAPI Implementation* at Cisco.com for information, http://www.cisco.com/en/US/docs/voice_ip_comm/cucm/tapi_dev/7_0_1/tpdevch4.html

AXL

The AXL API provides a mechanism for inserting, retrieving, updating, and removing data from the Cisco Unified Communications Manager database by using an eXtensible Markup Language (XML) Simple Object Access Protocol (SOAP) interface. This approach allows a programmer to access the database by using XML and receive the data in XML form, instead of by using a binary library or DLL.

The AXL API methods, known as requests, use a combination of HTTPS and SOAP. SOAP is an XML remote procedure call (RPC) protocol. The server receives the XML structures and executes the request. If the request completes successfully, the system returns the appropriate AXL response. All responses are named identically to the associated requests, except that the word “Response” is appended.

See *Cisco Unified Communications Manager XML Developers Guide Release 7.0(1)* at Cisco.com for information, http://www.cisco.com/en/US/docs/voice_ip_comm/cucm/devguide/7_0_1/ccmdvCh1.html.

Gatekeeper Transaction Message Protocol (GKTMP)

The Cisco Gatekeeper Transaction Message Protocol (GKTMP) and application programming interface (API) is available for your use.

See *GKTMP Commands (GK API Guide Version 4.4* at Cisco.com for the latest Gatekeeper API inputs and outputs, http://www.cisco.com/en/US/docs/ios/12_3/gktmpv4_3/guide/gk_cli.html.

Online Insertion and Removal

Online insertion and removal (OIR) is a feature that allows you to replace modules without turning off the router and without affecting the operation of other interfaces. OIR of a module provides uninterrupted operation to network users, maintains routing information, and ensures session preservation.

For instructions on inserting, removing, and replacing the module, see the hardware installation guide for your router at Cisco.com.

Configuring Next-Generation High-Density PVDM3 Modules

The next-generation packet voice/data module (PVDM3) digital signal processor (DSP) modules provide up to four times the density (per slot) of existing audio applications on Cisco voice gateway routers. One universal DSP image for these DSP modules provides resources for time-division multiplexing-to-Internet Protocol (TDM-to-IP) gateway functionality for digital and analog interfaces, audio transcoding, and audio conferencing.

This enhanced DSP architecture accommodates a new packet-processing engine for rich-media voice applications and supports the TDM voice framework used by the PVDM2 module. The PVDM3 has a Gigabit Ethernet interface with a MultiGigabit Fabric to increase IP throughput, and a DSP hardware-based health monitor provides DSP failure detection that is ten times faster than existing technology.

The DSP Resource Manager has been enhanced so that PVDM3 modules can pool DSP resources and share DSP resources across voice service modules when there is a combination of PVDM2-based (using 5510 DSP) modules and PVDM3-based modules in one router. This supports the coexistence of PVDM2, PVDM2-DM, and PVDM3 modules on *separate* boards in the same router. However, any PVDM2 modules inadvertently deployed on the same voice card as PVDM3 modules are shut down.

Note Different-generation PVDM types can exist on different voice cards within the same router, but not on the same voice card. Each voice card in a router can support only PVDM2 or PVDM3 modules. There cannot be a combination of the two different PVDM types on the same voice card. There can be only one type of PVDM on the router motherboard—either PVDM2 or PVDM3 modules—not a combination of the two.

PVDM2s can reside on a network module within a router that supports PVDM3 modules on the motherboard, but PVDM2 and PVDM3 modules cannot be mixed on the network module, and PVDM2s and PVDM3s may not be mixed on the router motherboard.

Contents

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- Restrictions for Configuring the PVDM3 Module on Cisco Voice Gateway Routers, page 182
- Information About Configuring the PVDM3 Module on Cisco Voice Gateway Routers, page 183

- How to Verify and Troubleshoot the Functionality of the PVDM3 Cards on Cisco Voice Gateways, page 190
- Configuration Examples for Configuring the PVDM3 Module on Cisco Voice Gateway Routers, page 197
- Additional References, page 202
- Glossary, page 204

Prerequisites for Configuring the PVDM3 Module on Cisco Voice Gateway Routers

To configure the PVDM3 Module on your Cisco 2900 or Cisco 3900 series voice gateway router, you must have Cisco IOS Release 15.0(1)M or a later release installed. The image must provide a voice-capable feature set.

To configure the PVDM3 Module on your Cisco 3925E or Cisco 3945E voice gateway router you must have Cisco IOS Release 15.1(1)T or later release installed. The image must provide a voice-capable feature set.

If you have installed the PVDM3 cards in your Cisco gateway, make certain that you have complied with the hardware installation instructions in *Cisco 2900 Series and 3900 Series Integrated Services Routers Hardware Installation Guide.*

Restrictions for Configuring the PVDM3 Module on Cisco Voice Gateway Routers

The PVDM3 card can only be installed and used on the following Cisco voice gateway routers:

- Cisco 2901 and Cisco 2911 (each router supports up to two PVDM3 modules)
- Cisco 2921 and Cisco 2951 (each router supports up to three PVDM3 modules)
- Cisco 3925 and Cisco 3945 (each router supports up to four PVDM3 modules)
- Cisco 3925E and Cisco 3945E (each router supports up to three PVDM3 modules)

All codecs that are supported on the PVDM2 are supported on the PVDM3, except that the PVDM3 does not support the G.723 (G.723.1 and G.723.1A) codecs. The PVDM2 can be used to provide G.723 codec support or the G.729 codec can be as an alternative on the PVDM3.

The PVDM3 DSP does not support Cisco Fax Relay. The PVDM2 (5510 DSP) does support Cisco Fax Relay.

The coexistence of PVDM2 and PVDM3 modules on the same motherboard is not supported. If these two modules are installed on the same motherboard, the PVDM2 is shut down.

Information About Configuring the PVDM3 Module on Cisco Voice Gateway Routers

To take full advantage of the PVDM3 cards on Cisco voice gateway routers, you should understand the following concepts:

- DSP Resource Manager Enhancement and DSP Numbering
- DSP Image for the PVDM3
- DSP Farms
- DSP Farm Profiles
- Conferencing
- Broadcast Fast Busy Tone for DSP Oversubscription

DSP Resource Manager Enhancement and DSP Numbering

Each PVDM3 DSP card can hold up to two devices, and each device can hold up to three DSP cores. The host recognizes each DSP card as one individual DSP and each physical DSP as a device. This virtual DSP concept provides a maximum of six DSPs per PVDM3. For backward compatibility for 5510 DSPs, the existing numbering scheme is maintained (see Table 1), and for PVDM3 DSPs, a new numbering scheme is applied (see Table 2).

Note The numbering schemes shown in Table 1 and Table 2 are examples only, and the DSP cards must be installed in the PVDM slots as shown for these sample numbering schemes to be correct. For more information about DSP and device numbering, see the documents listed in the "Additional References" section on page 202.

Table 1 Example of a DSP Numbering Scheme for 5510 Installation Only (Existing)

	PVDM slot 0	PVDM slot 1	PVDM slot 2	PVDM slot 3
5510 Only	**PVDM2-16**	**PVDM2-32**	**PVDM2-48**	**PVDM2-64**
DSP ID	1	5,6	9,10,11	13,14,15,16

Table 2 Example of a DSP Numbering Scheme for PVDM3 Only, PVDM2 Only, and Mixed Installation

	PVDM slot 0	PVDM slot 1	PVDM slot 2	PVDM slot 3
PVDM3 Only	**PVDM3-256**	**PVDM3-16**	**PVDM3-64**	**PVDM3-192**
DSP ID	1,2,3,4,5,6	7	13,14	19,20,21,22,23
Device ID	0,0,0,1,1,1	2	4,4	6,6,6,7,7
PVDM2 Only	**PVDM2-32**	**PVDM2-64**	**PVDM2-16**	**PVDM2-48**
DSP ID	1,2	5,6,7,8	9	13,14,15
Mixed Installation	**PVDM-DM**	**PVDM3-256**	**PVDM3-32**	—

Table 2 Example of a DSP Numbering Scheme for PVDM3 Only, PVDM2 Only, and Mixed Installation (continued)

	PVDM slot 0	PVDM slot 1	PVDM slot 2	PVDM slot 3
PVDM3 Only	**PVDM3-256**	**PVDM3-16**	**PVDM3-64**	**PVDM3-192**
DSP ID	1,2	23,24,25,26,27,28	29	—
Device ID	—	2,2,2,3,3,3	—	—

DSP Image for the PVDM3

The DSP image for the PVDM3 supports all features supported on PVDM2 except Cisco Fax Relay. The DSP image provides feature capability to implement the signal processing layer for a TDM-to-IP gateway:

- TDM-to-IP gateway for voice telephony, including support for multicast conferencing through the mixing of multiple IP streams out a single TDM port.
- Low-level processing of CAS from a T1/E1 interface through the use of digital signaling channels.
- Control and low-level processing of the signaling for analog telephony interface implemented on Cisco's voice interface card (VIC) hardware.
- Support for Voice Band Data (VBD) through the use of upspeeding channels.
- Support of facsimile using T.38 Fax Relay technology.
- Support of high-speed modems (V.32 and V.34) using Modem Relay technology.
- Interface with Secure Telephony (STU) phones using Secure Telephony over IP standard technology.
- Support for interfacing VoIP channel to Land Mobile Radio (LMR) networks.
- Support for secure VoIP through the implementation of SRTP for both encryption and authentication of RTP packets.
- Support for text telephony (Baudot) using Text Relay technology.

The DSP image for the PVDM3 also provides a complete set of features to implement the signal processing layer of an IP-to-IP gateway and an IP-based conference server. Highlights of this functionality include:

- G.711 transcoding for implementing a LAN-WAN gateway.
- Universal Transcoding between any two voice codecs (narrowband or wideband).
- Trans-scripting services for conversion between SRTP configurations or between secured and unsecured networks.
- IP-based voice conferencing, including narrowband and wideband participants.

DSP Farms

DSP Farm is enhanced to support increased transcoding and conference density. For DSPs on PVDM3 modules, existing resource allocation and management mechanisms are enhanced:

- For the PVDM3 DSP, participant-per-conference support is expanded to a maximum of 64. Note that this is supported only by low-complexity conference in Cisco IOS Release 15.0(1)M.
- Transcoding or conferencing channel allocation for a new call is modified to achieve load balancing. This is supported by the capability to select one channel from one DSP at a time.

DSP Farm Profiles

DSP-farm profiles are created to allocate DSP-farm resources. Under the profile, you select the service type (conference, transcode, or Media Termination Point [MTP]), associate an application, and specify service-specific parameters such as codecs and maximum number of sessions. A DSP-farm profile allows you to group DSP resources based on the service type. Applications associated with the profile, such as SCCP, can use the resources allocated under the profile. You can configure multiple profiles for the same service, each of which can register with one Cisco Unified Communications Manager group. The profile ID and service type uniquely identify a profile, allowing the profile to uniquely map to a Cisco Unified Communications Manager group that contains a single pool of Cisco Unified Communications Manager servers.

Conferencing

Voice conferencing involves adding several parties to a phone conversation. In a traditional circuit-switched voice network, all voice traffic passes through a central device such as a PBX. Conference services are provided within this central device. In contrast, IP phones normally send voice signals directly between phones, without the need to go through a central device. Conference services, however, require a network-based conference bridge.

In an IP telephony network using Cisco Unified Communications Manager, the Conferencing and Transcoding for Voice Gateway Routers feature provides the conference-bridging service. Cisco Unified Communications Manager uses a DSP farm to mix voice streams from multiple participants into a single conference-call stream. The mixed stream is played out to all conference attendees, minus the voice of the receiving attendee.

The Ad Hoc and Meet Me conferencing features are supported (a conference can be either of these types):

- Ad Hoc—The person controlling the conference presses the telephone conference button and adds callers one by one.
- Meet Me—Participants call in to a central number and are joined in a single conference.

Participants whose end devices use different codec types are joined in a single conference; no additional transcoding resource is needed.

Broadcast Fast Busy Tone for DSP Oversubscription

There should always be a dial tone when a telephone is lifted. However, when DSP oversubscription occurs, and a caller goes off-hook, dead-air is received. With this feature, the caller receives a fast-busy tone instead of silence. This feature is not supported on application-controlled endpoints, Foreign Exchange Office (FXO) signaling endpoints, and BRI and Primary Rate Interface (PRI) endpoints.

The following lists the maximum number of different fast busy tone (specific to country) that can be supported by each PVDM type:

- PVDM3-16 1
- PVDM3-32 1
- PVDM3-64 2
- PVDM3-128 3
- PVDM3-192 3
- PVDM3-256 3

Prior to Cisco IOS Release 15.0(1)M, a new call attempt failed and dead silence occurred when DSPs were oversubscribed. When the PVDM3 is installed, a fast busy tone is broadcast to session application endpoints when DSP oversubscription occurs for both analog ports and digital ports, except PRI and BRI. FXO signaling and application controlled endpoints are not supported. This feature does not apply to insufficient DSP credits due to mid-call codec changes (while a call is already established).

Online Insertion and Removal

Cisco 3900 Series ISRs support only managed online insertion and removal. All voice ports and controllers should be shut down. Transcoding, conferencing, and MTP DSPfarm profiles need to be shut down in addition to the controller and voice port shutdown. Also, remove the DSP sharing (that is, DS0-group and DSPfarm sharing).

If the power efficiency management is configured on the module, the **EnergyWise** level must be set to **10** or online insertion and removal is not allowed.

Perform the following tasks for managed online insertion and removal on the Cisco 3900 Series ISRs:

1. Shut down the controller and voice ports.
2. Perform online insertion and removal.
3. Restart the controller and voice ports.

Shut down the controller and voice ports

Perform the steps detailed in this section to shut down the controller and voice ports

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **controller e1** *slot/port*
4. **shutdown**
5. **exit**
6. **voice-port** *slot number/port*

7. **shutdown**
8. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enable privileged EXEC mode • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enter global configuration mode.
Step 3	**controller e1** *slot/port* **Example:** `Router(config)# controller e1 0/0/0`	Enter config-controller mode.
Step 4	**shutdown** **Example:** `Router(config-controller)# shutdown`	Administratively shuts down the controller port.
Step 5	**exit** **Example:** `Router(config-controller)# exit`	Exit config-controller mode.
Step 6	**voice-port** *slot number/port* **Example:** `Router(config)# voice-port 0/0/0:1`	Enter config-voiceport mode.
Step 7	**shutdown** **Example:** `Router(config-voiceport)# shutdown`	Administratively shuts down the voice port.
Step 8	**exit** **Example:** `Router(config-voiceport)# exit`	Exit config-voiceport mode. Use the **exit** command till you are in privileged EXEC mode.

Perform online insertion and removal

SUMMARY STEPS

1. **hw-module sm** *slot* **oir-stop**
2. Confirm that the board is ready for removal.The LED blinks for 3 seconds and turns off. After the LED is off, the board is ready for removal.
3. Insert the replacement board in the same slot or in an empty slot.
4. **hw-module sm** *slot* **oir-start**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**hw-module sm** *slot* **oir-stop** **Example:** `Router# hw-module sm 1 oir-stop`	Shuts down the specified module to prepare it for removal.
Step 2	Wait until the LED signals that the board is ready for removal. The LED blinks for 3 seconds and turns off. After the LED is off, the board is ready for removal.	
Step 3	Insert the replacement board in the same slot or in an empty slot.	
Step 4	**hw-module sm** *slot* **oir-start** **Example:** `Router# hw-module sm 1 oir-start`	Restores power to the module.

Restart the controller and voice ports

SUMMARY STEPS

1. **configure terminal**
2. **controller e1** *slot/port*
3. **no shutdown**
4. **exit**
5. **voice-port** *slot number/port*
6. **no shutdown**
7. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 2	**controller e1** *slot/port* **Example:** `Router(config)# controller e1 0/0/0`	Enters config-controller mode.
Step 3	**no shutdown** **Example:** `Router(config-controller)# no shutdown`	Restarts the controller port.
Step 4	**exit** **Example:** `Router(config-controller)# exit`	Exits config-controller mode.
Step 5	**voice-port** *slot number/port* **Example:** `Router(config)# voice-port 0/0/0:1`	Enters config-voiceport mode.
Step 6	**no shutdown** **Example:** `Router(config-voiceport)# no shutdown`	Restarts the voice port.
Step 7	**exit** **Example:** `Router(config-voiceport)# exit`	Exits config-voiceport mode.

TDM Sharing/Pooling Configuration

Time-division multiplexing (TDM) sharing/pooling is only allowed among the same type of PVDMs. For example, if the motherboard has PVDM3 modules, and other voice cards have PVDM2 modules, the motherboard cannot share or pool DSP resources with other voice cards. If the motherboard has PVDM2 modules, and other voice cards also have PVDM2 modules, the existing CLI command will enable TDM sharing/pooling:

```
voice-card 0
 dsp tdm pooling
```

In the case of mixed types of PVDMs existing in the router (for example, the motherboard has PVDM3, another voice card has PVDM2, and a third voice card has no PVDM), there is a new CLI command under the **voice card** CLI that allows the voice card to choose which type of PVDM to use for TDM sharing/pooling:

```
voice-card 2
 dsp tdm pooling type [PVDM2 | PVDM3]
```

For more information about TDM sharing/pooling, see the documents listed in the "Additional References" section on page 202.

How to Verify and Troubleshoot the Functionality of the PVDM3 Cards on Cisco Voice Gateways

Use the following commands in global configuration mode to verify and troubleshoot the functionality of the PVDM2 and PVDM3 modules in your Cisco voice gateway.

SUMMARY STEPS

1. **show platform hw-module-power**
1. **show voice call** *slot/port*
2. **show voice dsp group all**
3. **show voice dsp sorted-list**
4. **show voice dsp capabilities slot** *number* **dsp** *number*
5. **show voice dsp group slot** *number*
6. **show voice dsp statistics device**
7. **show voice dsp statistics tx-rx**
8. **show voice dsp statistics ack**
9. **debug voice dsp crash-dump**

DETAILED STEPS

Step 1 **show platform hw-module-power**

Note Effective with Cisco IOS Releases 15.1(1)T and 15.0.1M(2), the **hw-module energywise level** command is not available in Cisco IOS software. For more information, see the *Cisco 3900 Series, 2900 Series, and 1900 Series Software Configuration Guide*.

Use this command to display power settings of PVDM3 service modules, for example:

```
Router# show platform hw-module-power

PVDM:
    Slot 0/1
        Levels supported 0x441 :  SHUT FRUGAL FULL
        CURRENT level  : 10 (FULL)
        Previous level : 10 (FULL)
        Transitions  : Successful Unsuccessful
        SHUT         : 0          0
        FRUGAL       : 0          0
        FULL         : 0          0

    Slot 0/2
        Levels supported 0x441 :  SHUT FRUGAL FULL
        CURRENT level  : 10 (FULL)
        Previous level : 0 (SHUT)
        Transitions  : Successful Unsuccessful
        SHUT         : 1          0
        FRUGAL       : 0          1
        FULL         : 1          0

    Slot 0/3
        Levels supported 0x441 :  SHUT FRUGAL FULL
        CURRENT level  : 10 (FULL)
        Previous level : 10 (FULL)
        Transitions  : Successful Unsuccessful
        SHUT         : 0          0
        FRUGAL       : 0          0
        FULL         : 0          0
```

Step 2 **show voice call** *slot/port*

Note If you are connected using a Telnet session, you must enter the **terminal monitor** command before the **show voice call** command to see console messages. This step is not necessary if you are connected to the console port.

Use this command to display statistics for voice calls on a specific slot and port, for example:

```
Router# show voice call  0/1/1:23

0/1/1:23 1
      vtsp level 0 state = S_CONNECT
callid 0x0011 B01 state S_TSP_CONNECT clld 4085001112 cllg 4085001112
0/1/1:23 2
      vtsp level 0 state = S_CONNECT
callid 0x0012 B02 state S_TSP_CONNECT clld 4085001112 cllg 4085001112
0/1/1:23 3 -          -  -
0/1/1:23 4 -          -  -
```

```
0/1/1:23 5 -          -  -
0/1/1:23 6 -          -  -
0/1/1:23 7 -          -  -
0/1/1:23 8 -          -  -
0/1/1:23 9 -          -  -
0/1/1:23 10-          -  -
0/1/1:23 11-          -  -
0/1/1:23 12-          -  -
0/1/1:23 13-          -  -
0/1/1:23 14-          -  -
0/1/1:23 15-          -  -
0/1/1:23 16-          -  -
0/1/1:23 17-          -  -
0/1/1:23 18-          -  -
0/1/1:23 19-          -  -
0/1/1:23 20-          -  -
0/1/1:23 21-          -  -
0/1/1:23 22-          -  -
0/1/1:23 23-          -  -
```

Step 3 show voice dsp group all

Use this command to display information for each DSP group, for example:

```
Router# show voice dsp group all

DSP groups on slot 0:
dsp 1:
  State: UP, firmware: 26.0.135
  Max signal/voice channel: 43/43
  Max credits: 645
  num_of_sig_chnls_allocated: 35
  Transcoding channels allocated: 0
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 630, reserved credits: 0
    Signaling channels allocated: 35
    Voice channels allocated: 1
    Credits used (rounded-up): 15
    Voice channels:
      Ch01: voice port: 0/1/1:23.2, codec: g711alaw, credits allocated: 15
  Slot: 0
  Device idx: 0
  PVDM Slot: 0
  Dsp Type: SP2600

dsp 2:
  State: UP, firmware: 26.0.135
  Max signal/voice channel: 43/43
  Max credits: 645
  num_of_sig_chnls_allocated: 0
  Transcoding channels allocated: 0
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 645, reserved credits: 0
    Signaling channels allocated: 0
    Voice channels allocated: 0
    Credits used (rounded-up): 0
  Slot: 0
  Device idx: 0
  PVDM Slot: 0
  Dsp Type: SP2600

dsp 3:
  State: UP, firmware: 26.0.135
  Max signal/voice channel: 42/43
```

```
  Max credits: 645
  num_of_sig_chnls_allocated: 0
  Transcoding channels allocated: 0
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 645, reserved credits: 0
    Signaling channels allocated: 0
    Voice channels allocated: 0
    Credits used (rounded-up): 0
  Slot: 0
  Device idx: 0
  PVDM Slot: 0
  Dsp Type: SP2600

dsp 4:
  State: UP, firmware: 26.0.135
  Max signal/voice channel: 43/43
  Max credits: 645
  num_of_sig_chnls_allocated: 0
  Transcoding channels allocated: 0
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 645, reserved credits: 0
    Signaling channels allocated: 0
    Voice channels allocated: 0
    Credits used (rounded-up): 0
  Slot: 0
  Device idx: 1
  PVDM Slot: 0
  Dsp Type: SP2600

dsp 5:
  State: UP, firmware: 26.0.135
  Max signal/voice channel: 43/43
  Max credits: 645
  num_of_sig_chnls_allocated: 0
  Transcoding channels allocated: 0
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 645, reserved credits: 0
    Signaling channels allocated: 0
    Voice channels allocated: 0
    Credits used (rounded-up): 0
  Slot: 0
  Device idx: 1
  PVDM Slot: 0
  Dsp Type: SP2600

dsp 6:
  State: UP, firmware: 26.0.135
  Max signal/voice channel: 42/43
  Max credits: 645
  num_of_sig_chnls_allocated: 0
  Transcoding channels allocated: 0
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 645, reserved credits: 0
    Signaling channels allocated: 0
    Voice channels allocated: 0
    Credits used (rounded-up): 0
  Slot: 0
  Device idx: 1
  PVDM Slot: 0
  Dsp Type: SP2600
```

```
dsp 7:
  State: UP, firmware: 26.0.135
  Max signal/voice channel: 32/32
  Max credits: 480
  num_of_sig_chnls_allocated: 0
  Transcoding channels allocated: 0
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 465, reserved credits: 0
    Signaling channels allocated: 0
    Voice channels allocated: 1
    Credits used (rounded-up): 15
    Voice channels:
      Ch01: voice port: 0/1/1:23.1, codec: g711alaw, credits allocated: 15
  Slot: 0
  Device idx: 0
  PVDM Slot: 1
  Dsp Type: SP2600


DSP groups on slot 1:

DSP groups on slot 2:
dsp 1:
  State: UP, firmware: 26.0.133
  Max signal/voice channel: 16/16
  Max credits: 240
  num_of_sig_chnls_allocated: 0
  Transcoding channels allocated: 0
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 240, reserved credits: 0
    Signaling channels allocated: 0
    Voice channels allocated: 0
    Credits used (rounded-up): 0

dsp 2:
  State: UP, firmware: 26.0.133
  Max signal/voice channel: 16/16
  Max credits: 240
  num_of_sig_chnls_allocated: 0
  Transcoding channels allocated: 0
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 240, reserved credits: 0
    Signaling channels allocated: 0
    Voice channels allocated: 0
    Credits used (rounded-up): 0

dsp 3:
  State: UP, firmware: 26.0.133
  Max signal/voice channel: 16/16
  Max credits: 240
  num_of_sig_chnls_allocated: 0
  Transcoding channels allocated: 0
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 240, reserved credits: 0
    Signaling channels allocated: 0
    Voice channels allocated: 0
    Credits used (rounded-up): 0
```

```
dsp 4:
  State: UP, firmware: 26.0.133
  Max signal/voice channel: 16/16
  Max credits: 240
  num_of_sig_chnls_allocated: 0
  Transcoding channels allocated: 0
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 240, reserved credits: 0
    Signaling channels allocated: 0
    Voice channels allocated: 0
    Credits used (rounded-up): 0


DSP groups on slot 3:
 This command is not applicable to slot 3

DSP groups on slot 4:
 This command is not applicable to slot 4

  2 DSP resource allocation failure
```

Step 4 **show voice dsp sorted-list**

Use this command to display the hunt order in which DSPs are utilized for particular services (in this example, voice, conferencing, and transcoding are shown for slot 0):

```
Router# show voice dsp sorted-list slot 0

DSP id selection list for different service for Card 0:
=======================================================
Voice :01,02,03,04,05,06,07
Conf  :07,06,05,04,03,02,01
Xcode :01,02,03,04,05,06,07
```

Step 5 **show voice dsp capabilities slot** *number* **dsp** *number*

Use this command to display capabilities data for a particular DSP on a particular slot (in this example, DSP 2 on slot 0):

```
Router# show voice dsp capabilities slot 0 dsp 2

DSP Type: SP2600 -43
Card 0 DSP id 2 Capabilities:
    Credits   645 ,  G711Credits 15,  HC Credits  32,  MC Credits  20,
    FC Channel  43,  HC Channel  20,  MC Channel  32,
    Conference 8-party credits:
     G711  58 ,  G729  107,  G722  129,  ILBC  215
Secure Credits:
    Sec LC Xcode  24,      Sec HC Xcode  64,
    Sec MC Xcode  35,      Sec G729 conf 161,
    Sec G722 conf 215,     Sec ILBC conf 322,
    Sec G711 conf 92 ,
Max Conference Parties per DSP:
    G711 88,  G729 48,  G722 40,  ILBC 24,
    Sec G711 56,  Sec G729 32,
    Sec G722 24  Sec ILBC 16,
```

```
Voice Channels:
    g711perdsp = 43,  g726perdsp = 32, g729perdsp = 20, g729aperdsp = 32,
    g723perdsp = 20,  g728perdsp = 20, g723perdsp = 20, gsmperdsp   = 32,
    gsmefrperdsp = 20, gsmamrnbperdsp = 20,
    ilbcperdsp = 20, modemrelayperdsp = 20
    g72264Perdsp = 32, h324perdsp = 20,
    m_f_thruperdsp = 43, faxrelayperdsp = 32,
    maxchperdsp = 43, minchperdsp = 20,
    srtp_maxchperdsp = 27, srtp_minchperdsp = 14, faxrelay_srtp_perdsp = 14,
    g711_srtp_perdsp = 27, g729_srtp_perdsp = 14, g729a_srtp_perdsp = 24,
```

Step 6 **show voice dsp group slot** *number*

Use this command to display the current status or selective statistics of DSP voice channels for a specific DSP group. For example:

```
Router# show voice dsp group slot 0
dsp 1:
  State: UP, firmware: 8.4.0
  Max signal/voice channel: 16/16
  Max credits: 240
  Group: FLEX_GROUP_VOICE, complexity: FLEX
    Shared credits: 240, reserved credits: 0
    Signaling channels allocated: 0
    Voice channels allocated: 0
     Credits used: 0
    Oversubscription: can either be an indicator or a counter
    DSP type: SP260x
```

Step 7 **show voice dsp statistics device**

Use this command to display DSP voice statistics for the device:

```
Router# show voice dsp statistics device

DEVICE  DSP CURR  AI/RST/WDT   ACK      MAC          TX/RX PACK            KEEPALIVE
ID      ID  STATE COUNT        FAIL    ADDRESS       COUNT                 TX/RX/SKP
======= === ===== ========= ===== ============= ================== =============
0/0/0     1   1   0/0/0        0     00fa.ce25.0000  51645919/37972871     29875/29875/0
0/0/0     2   1   0/0/0        0     00fa.ce25.0000  51645919/37972871     29875/29875/0
0/0/0     3   1   0/0/0        0     00fa.ce25.0000  51645919/37972871     29875/29875/0
0/0/1     4   1   0/0/0        0     00fa.ce25.0001  28355309/20859980     29875/29875/0
0/0/1     5   1   0/0/0        0     00fa.ce25.0001  28355309/20859980     29875/29875/0
0/0/1     6   1   0/0/0        0     00fa.ce25.0001  28355309/20859980     29875/29875/0
```

Step 8 **show voice dsp statistics tx-rx**

Use this command to display transmitted and received packet counts for the device:

```
Router# show voice dsp statistics tx-rx

Device and Port Statistics: PVDM-0
-----------------------------------
8903 input packets at port, 15374 output packets at port
Device 0:
6853 packets from device, 11793 packets to device
0 Ctrl & 0 Media out of sequence packets, 0 packets drop
0 input error packets, 0 output error packets
0 resource errors packets, 0 gaints
vlan id: 2
```

```
Device 1:
2048 packets from device, 3579 packets to device
0 Ctrl & 0 Media out of sequence packets, 0 packets drop
0 input error packets, 0 output error packets
0 resource errors packets, 0 gaints
vlan id: 2

Device and Port Statistics: PVDM-1
-----------------------------------
29083 input packets at port, 32627 output packets at port
Device 2:
29081 packets from device, 32627 packets to device
0 Ctrl & 0 Media out of sequence packets, 0 packets drop
0 input error packets, 0 output error packets
0 resource errors packets, 0 gaints
vlan id: 2

BP throttle change count 0, Current throttle flag 0
TX messages at congestion count 0
```

Step 9 **show voice dsp statistics ack**

Use this command to display ACK statistics for the device:

```
Router# show voice dsp statistics ack

DSP ACK   RETRY  TOTAL           WAITING
ID  DEPTH COUNT  RETRANSMITTION  FOR ACK
=== ===== ====== ==============  ========
ACK is enabled
```

Step 10 **debug voice dsp crash-dump**

Use this command to display debugging information for the crash dump feature (for detailed information about this, see the section *Voice DSP Crash Dump File Analysis* in *Cisco IOS Voice Troubleshooting and Monitoring Guide*):

```
Router# debug voice dsp crash-dump keepalives
```

Configuration Examples for Configuring the PVDM3 Module on Cisco Voice Gateway Routers

This section provides an example of a running configuration. This example is for reference purposes only and contains IP addresses and telephone numbers that are not actual, valid addresses and telephone numbers; they are provided for illustrative purposes only.

show running-config: Example

```
Router# show running-config
Building configuration...

! voice-card 0:
! Mixed PVDM3 and PVDM2 C5510 DSP cards detected.
! Mixed DSP types in this slot is an unsupported configuration.
! PVDM2 C5510 DSP cards have been disabled.


Current configuration : 3726 bytes
!
version 12.4
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Router
!
boot-start-marker
boot-end-marker
!
card type t1 0 0
card type t1 2 0
card type t1 2 1
logging message-counter syslog
logging buffered 10000000
!
no aaa new-model
clock timezone PST 8
no network-clock-participate slot 2
network-clock-participate wic 0
network-clock-select 1 T1 0/0/1
!
no ipv6 cef
ip source-route
ip cef
!
!
!
!
ip host hostname 223.255.254.254 255.255.255.255
ntp update-calendar
ntp server 10.1.32.153
ntp peer 10.1.32.153
multilink bundle-name authenticated
!
!
!
!
isdn switch-type primary-ni
!
!
!
voice-card 0
 dsp services dspfarm
!
voice-card 2
!
!
!
```

```
voice service voip
 allow-connections h323 to h323
 allow-connections h323 to sip
 allow-connections sip to h323
 allow-connections sip to sip
 fax protocol cisco
!
!
!
archive
 log config
  hidekeys
!
!
controller T1 0/0/0
 cablelength long 0db
 ds0-group 1 timeslots 1-24 type e&m-immediate-start
!
controller T1 0/0/1
 cablelength long 0db
 pri-group timeslots 1-24
!
controller T1 2/0
!
controller T1 2/1
!
controller T1 2/0/0
 cablelength long 0db
!
controller T1 2/0/1
 cablelength long 0db
!
!
!
!
interface GigabitEthernet0/0
 mtu 9600
 ip address 10.1.32.147 255.255.0.0
 duplex auto
 speed auto
 no cdp enable
!
interface GigabitEthernet0/1
 mtu 9600
 ip address 10.1.1.1 255.255.255.0
 duplex auto
 speed auto
 media-type rj45
 no cdp enable
!
interface GigabitEthernet0/2
 no ip address
 shutdown
 duplex auto
 speed auto
 no cdp enable
!
interface Serial0/0/1:23
 no ip address
 encapsulation hdlc
 isdn switch-type primary-ni
 isdn incoming-voice voice
 no cdp enable
!
```

```
ip forward-protocol nd
ip route 223.255.254.254 255.255.255.255 10.1.0.1
!
no ip http server
no ip http secure-server
!
!
!
nls resp-timeout 1
cpd cr-id 1
!
!
control-plane
!
!
!
voice-port 0/0/0:1
!
voice-port 0/0/1:23
!
!
mgcp fax t38 ecm
!
sccp local GigabitEthernet0/0
sccp ccm 10.1.32.147 identifier 1 priority 1 version 5.0.1
sccp
!
sccp ccm group 1
 associate ccm 1 priority 1
 associate profile 3 register CONFERENCE
 associate profile 2 register UNIVERSAL
 associate profile 1 register G711_ANY
!
dspfarm profile 1 transcode
 codec g711ulaw
 codec g711alaw
 codec g722-64
 maximum sessions 40
 associate application SCCP
!
dspfarm profile 2 transcode universal
 codec g723r63
 codec ilbc
 codec g729r8
 codec g729br8
 codec g723r53
 maximum sessions 10
 associate application SCCP
!
dspfarm profile 3 conference
 codec g711ulaw
 codec g711alaw
 codec g729ar8
 codec g729abr8
 codec g729r8
 codec g729br8
 maximum conference-participants 32
 maximum sessions 2
 associate application SCCP
 shutdown
!
!
```

```
dial-peer voice 201 voip
 session protocol sipv2
 incoming called-number 408555....
 codec g711ulaw
 no vad
!
dial-peer voice 202 voip
 destination-pattern 408555[0-4]...
 session protocol sipv2
 session target ipv4:10.1.32.153
 codec g722-64
 no vad
!
dial-peer voice 203 voip
 destination-pattern 408555[5-9]...
 session protocol sipv2
 session target ipv4:10.1.32.153
 codec g723r53
!
!
!
!
gatekeeper
 shutdown
!
!
telephony-service
 sdspfarm units 5
 sdspfarm transcode sessions 128
 sdspfarm tag 1 G711_ANY
 sdspfarm tag 2 UNIVERAL
 sdspfarm tag 4 CONFERENCE
 max-ephones 40
 max-dn 80
 ip source-address 10.1.32.147 port 2000
 max-conferences 32 gain -6
 transfer-system full-consult
 create cnf-files version-stamp Jan 01 2002 00:00:00
!
alias exec dsp show voice dsp group slot 0
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 login
!
exception data-corruption buffer truncate
scheduler allocate 20000 1000
no process cpu autoprofile hog
end
```

Additional References

The following sections provide references related to the PVDM3 on Cisco Gateway Routers feature.

Related Documents

Related Topic	Document Title
Comprehensive command reference information for Cisco IOS voice commands.	*Cisco IOS Voice Command Reference*
Configuration information for Cisco Voice Gateway Routers that are configured for Cisco Unified Communications Manager.	*Cisco Unified Communications Manager and Cisco IOS Interoperability Guide*
Complete hardware installation instructions for installing the PVDM3.	*Cisco 2900 Series and 3900 Series Integrated Services Routers Hardware Installation Guide*

Standards

Standard	Title
None	—

MIBs

MIB	MIBs Link
CISCO-DSP-MGMT-MIB	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at: http://www.cisco.com/go/mibs

RFCs

RFC	Title
None	—

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for Configuring the PVDM3 Module on Cisco Voice Gateway Routers

Table 3 lists the release history for this feature.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account at Cisco.com is not required.

Note Table 3 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 3 Feature Information for Configuring the PVDM3 Module on Cisco Voice Gateway Routers

Feature Name	Releases	Feature Information
Configuring the PVDM3 Module on Cisco Voice Gateway Routers	15.0(1)M 15.1(1)T 15.1(4)M	The PVDM3 DSP[1] modules support high-density audio applications on the Cisco voice gateways. These DSP modules provide resources for voice termination, voice compression algorithms, echo cancellation, conferencing and transcoding, and support for modems and fax calls. In Release 15.0(1)M, this feature is supported only on the Cisco 2901, Cisco 2911, Cisco 2921, Cisco 2951, Cisco 3925, and Cisco 3945. In Release 15.1(1)T, this feature is supported only on the Cisco 3925E and Cisco 3945E ISRs.

1. DSP = digital signal processor

Glossary

AGC—Automatic Gain Control.

BCN—Backward Congestion Notification.

CM—Connection manager (TDM).

COS—Class of service, 802.1p.

DA—Ethernet Destination Address.

DMA—Direct Memory Access.

DSA—Distributed Switch Architecture.

DSP—Digital Signal Processor.

DSPRM—DSP Resource Manager.

DTMF—Dual-tone multi-frequency.

ECAN—Echo Canceller.

EVSM—Extended Voice Service Module.

FC—Flex Complexity.

FPGA—Field-Programmable Gate Array.

HC—High Complexity.

HDLC—High-level Data Link Control Protocol.

HPI—Host Port Interface.

LC—Low Complexity.

MAC—Media Access Control.

MC—Medium Complexity.

McBSP—Multi-Channel Buffer Serial Port.

MTBF—Mean Time Between Failures.

MTP—Media Termination Point.

NTE—Named Telephone Events.

OIR—Online Insertion and Removal.

PCE—Packet Classification Engine.

PVDM3—Next generation Packet Voice Data Module.

PVDM2—PVDM hosting 5510 DSP.

QOS—Quality of Service.

REA—Ethernet Ready Announcement, like bootp message.

RI—Restart indication from DSP/Device.

RTP—Real-time Transport Protocol.

SA—Ethernet source address.

SGMII—Serial Gigabit Media Independent Interface.

SM—Service Module.

SRTP—Secure Real-time Transport Protocol.

TDM—Time Division Multiplexing.

UHPI—Universal Host Port Interface.

VIC—Voice Interface Card.

VLAN—Virtual LAN.

VNM—Voice Network Module.

VWIC—Voice/WAN Interface Card.

Configuring Multi-Gigabit Fabric Communication

Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series ISRs use a multi-gigabit fabric (MGF) for the new modules and interface cards to inter-communicate on the router. Legacy modules that support Cisco High-Speed Intrachassis Module Interconnect (HIMI) also support the MGF. Next generation module drivers integrate with the MGF to perform port configurations, configure packet flow, and control traffic buffering. On the router-side, there are no user-configurable features on the MGF. All configurations are performed from the module, which may or may not lead to changes on the MGF.

Modules and interface cards inter-communicate using the MGF on the router with or without CPU involvement. Modules and interface cards that communicate without CPU involvement reduce load and increase performance on the router. Modules and interface cards that do not utilize the MGF communicate with the CPU using the PCI Express (PCIe) link.

The following sections describe module and interface card communication through the MGF:

- Restrictions for Module and Interface Card Communication, page 207
- Supported Slots, Modules, and Interface Cards, page 207
- Cisco High-Speed Intrachassis Module Interconnect (HIMI), page 209
- Viewing Platform Information, page 210

Restrictions for Module and Interface Card Communication

Cisco 1941W

The wireless LAN (WLAN) module is only supported on the Cisco 1941W ISR.

Maximum Number of Legacy Switch Modules

A maximum of two integrated switch modules are supported when a legacy module is present in the system. In this scenario, the two switch modules have to be externally stacked.

Supported Slots, Modules, and Interface Cards

The following slots support communication through the MGF:

- Service module (SM)
- Enhanced high-speed WAN interface card (EHWIC)
- Internal service module (ISM)

The following modules and interface cards support communication through the MGF:

- Wireless LAN Module in the Cisco 1941W ISR, page 208
- Cisco Etherswitch Service Modules, page 208

Cisco 3900 Series, Cisco 2900 Series, and Cisco 1900 Series Integrated Services Routers support legacy interface cards and modules. Some modules will require an adapter. See your router's hardware installation guide at Cisco.com for adapter installation information.

See the routers's Product page at Cisco.com for a complete list of supported new and legacy modules.

Wireless LAN Module in the Cisco 1941W ISR

When configured as an autonomous access point, the wireless LAN (WLAN) device serves as the connection point between wireless and wired networks or as the center point of a stand-alone wireless network. In large installations, wireless users within radio range of a device can roam throughout a facility while maintaining seamless and uninterrupted access to the network.

Cisco 1941W supports ISM-to-EHWIC communication with an integrated switch communicating through the MGF. In this scenario traffic goes from the WLAN, through the Multi-Gigabit Fabric's CPU port, and out through a port on the front panel.

Cisco Etherswitch Service Modules

The following Cisco EtherSwitch service modules provide Cisco modular access routers the ability to stack Cisco EtherSwitch service modules as Layer 2 switches using Cisco StackWise technology.

- NME-16ES-1G
- NME-16ES-1G-P
- NME-X-23ES-1G
- NME-X-23ES-1G-P
- NME-XD-48ES-2S-P
- NME-XD-24ES-1S-P

The Cisco EtherSwitch service modules are supported by either the IP base image (formerly known as standard multilayer image [SMI]) or the IP services image (formerly known as the enhanced multilayer image [EMI]).

The IP base image provides Layer 2+ features, including access control lists, quality of service (QoS), static routing, and the Routing Information Protocol (RIP). The IP services image provides a richer set of enterprise-class features, including Layer 2+ features and full Layer 3 routing (IP unicast routing, IP multicast routing, and fallback bridging). To distinguish it from the Layer 2+ static routing and RIP, the IP services image includes protocols such as the Enhanced Interior Gateway Routing Protocol (EIGRP) and the Open Shortest Path First (OSPF) Protocol.

Cisco 3900 Series, Cisco 2900 Series, and Cisco 1900 Series Integrated Services Routers support the following Cisco EtherSwitch service modules for SM-to-SM or SM-to-ISM communication.

- NME-16ES-1G
- NME-16ES-1G-P
- NME-X-23ES-1G
- NME-X-23ES-1G-P

- NME-XD-48ES-2S-P
- NME-XD-24ES-1S-P

See the *Cisco EtherSwitch Feature Guide* documentation at Cisco.com for configuration details, http://www.cisco.com/en/US/docs/ios/12_3t/12_3t14/feature/guide/miragenm.html#wp1787811.

Cisco High-Speed Intrachassis Module Interconnect (HIMI)

Cisco 3900 series and Cisco 2900 series routers use Cisco High-Speed Intrachassis Module Interconnect (HIMI) to support SM-to-SM or SM-to-ISM communication through the MGF.

Use the **connect** *connection-name* **module** *Module1 Channel-id1* **module** *Module2 Channel-id2* command to establish a maximum of two HIMI connections on the Cisco 3900 series ISR routers and one HIMI connection on Cisco 2900 series andCisco 1900 series ISRs. Module 1 and Module 2 are the slot/port of the two modules. The *Channel-id1* and *Channel-id2* variables must always have a value of 0.

When two modules are configured in a HIMI connection, the modules cannot send traffic to any other module except its HIMI-dedicated partner.

See *Cisco High-Speed Intrachassis Module Interconnect (HIMI) Configuration Guide* at Cisco.com for detailed configuration instructions, http://www.cisco.com/en/US/docs/ios/12_4/12_4_mainline/srdesfm1.html.

Note See the module documentation to validate HIMI support.

Using HIMI for VLAN Traffic Flows

For HIMI configurations, the port-level VLAN memberships are ignored on the Multi-Gigabit Fabric (MGF). Use the **connect** *connection-name* **module** *module1 vlan-id* **module** *module2* command to redirect VLAN traffic flows from SM-to-SM or SM-to-ISM connections on the MGF.

The following two modules, as well as others, support VLAN traffic redirection:

- Cisco Etherswitch service module
- Cisco Services Ready Engine internal service module (ISM-SRE)

Note See the module documentation to validate HIMI support.

Viewing Platform Information

The following sections explain how to view VLAN, slot, module, interface card, and MGF statistics on the router.

- Viewing VLAN and Slot Assignments, page 210
- Viewing Module and Interface Card Status on the Router, page 210
- Viewing Multi-Gigabit Fabric Statistics, page 211

Viewing VLAN and Slot Assignments

Slots on the router are optionally assigned to VLANs. From privileged EXEC mode, enter the **show platform mgf** command, then press Enter to display VLAN and slot assignments on the router. An asterisk next to the slot indicates that the vlan is the slot's default VLAN. The following example displays output from a Cisco 3945 ISR.

Note VLAN1 is the default when no other VLAN are listed.

```
Router# show platform mgf
VLAN    Slots
---------------------------------------------------------
1       ISM*, EHWIC-0*, EHWIC-1*, EHWIC-2*, EHWIC-3*
        PVDM-0*, PVDM-1*, PVDM-2*, PVDM-3*, SM-1*
        SM-2*, SM-3*, SM-4*
```

Viewing Module and Interface Card Status on the Router

Multi-gigabit Fabric (MGF) displays module and interface card details. To show the details of the MGF, use the **show platform mgf** command in privileged EXEC mode.

The following example displays the output for the **show platform mgf module** command when entered on a Cisco 3945 ISR. Table 1 on page 211 displays the information code that appears in the output.

```
Router# show platform mgf module
Registered Module Information
Code:   NR - Not Registered, TM - Trust Mode, SP - Scheduling Profile
        BL - Buffer Level, TR - Traffic Rate, PT - Pause Threshold

slot    vlan    type/ID         TM      SP      BL      TR      PT
----    ----    ----------      ------- ---     ------  -----   ----
ISM     NR
EHWIC-0 NR
EHWIC-1 NR
EHWIC-2 NR
EHWIC-3 NR
PVDM-0  NR
PVDM-1  NR
PVDM-2  NR
PVDM-3  NR
SM-1     1       SM/6            UP      1       high    1000    high
SM-2     1       SM/6            UP      1       high    1000    high
SM-3    NR
SM-4    NR
```

Table 1 Show Platform MGF Module Information Code

Code	Description
NR	Not registered
TM	Trust mode (User Priority [UP] or Differentiated Service Code [DSCP])
SP	Scheduling profile
BL	Buffer level
TR	Traffic rate
PT	Pause threshold level

Viewing Multi-Gigabit Fabric Statistics

Statistics reports for each slot show packet performance and packet failures. The following example displays output from the **show platform mgf statistics** command when entered on a Cisco 1941 ISR.

```
Router# show platform mgf statistics

Interface statistics for slot: ISM (port 1)
-----------------------------------------------------
30 second input rate 0 packets/sec
30 second output rate 0 packets/sec
0 packets input, 0 bytes, 0 overruns
Received 0 broadcasts, 0 multicast, 0 unicast 0 runts, 0 giants, 0 jabbers 0 input errors,
0 CRC, 0 fragments, 0 pause input 0 packets output, 0 bytes, 0 underruns 0 broadcast, 0
multicast, 0 unicast 0 late collisions, 0 collisions, 0 deferred 0 bad bytes received, 0
multiple, 0 pause output

Interface statistics for slot: EHWIC-0 (port 2)
-----------------------------------------------------
30 second input rate 13844 packets/sec
30 second output rate 13844 packets/sec
3955600345 packets input, 1596845471340 bytes, 26682 overruns Received 0 broadcasts, 0
multicast, 3955600345 unicast 0 runts, 0 giants, 0 jabbers 0 input errors, 0 CRC, 0
fragments, 0 pause input
3955738564 packets output, 1596886171288 bytes, 0 underruns 0 broadcast, 0 multicast,
3955738564 unicast 0 late collisions, 0 collisions, 0 deferred 0 bad bytes received, 0
multiple, 94883 pause output

Interface statistics for slot: EHWIC-1 (port 3)
-----------------------------------------------------
30 second input rate 13844 packets/sec
30 second output rate 13844 packets/sec
3955973016 packets input, 1598763291608 bytes, 26684 overruns Received 0 broadcasts, 0
multicast, 3955973016 unicast 0 runts, 0 giants, 0 jabbers 0 input errors, 0 CRC, 0
fragments, 0 pause input 3955781430 packets output, 1598708166660 bytes, 0 underruns 0
broadcast, 0 multicast, 3955781430 unicast 0 late collisions, 0 collisions, 0 deferred 0
bad bytes received, 0 multiple, 94987 pause output
```

Viewing Multi-Gigabit Fabric CPU Port Statistics

Multi-Gigabit Fabric's CPU port statistics display details about the hardware status, data transmission rate, line type, protocols, and packets. The following example displays output for the **show platform mgf statistics cpu** command when entered on a Cisco 3945 ISR.

```
Router# show platform mgf statistics cpu
Backplane-GigabitEthernet0/3 is up, line protocol is up
  Hardware is PQ3_TSEC, address is 001b.5428.d403 (bia 001b.5428.d403)
  MTU 9600 bytes, BW 1000000 Kbit/sec, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Full-duplex, 1000Mb/s, media type is internal
  output flow-control is unsupported, input flow-control is unsupported
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 watchdog, 0 multicast, 0 pause input
     0 input packets with dribble condition detected
     0 packets output, 0 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier, 0 pause output
     0 output buffer failures, 0 output buffers swapped out Interface statistics for CPU:
(port 0)
------------------------------------------------------
30 second input rate 0 packets/sec
30 second output rate 0 packets/sec
0 packets input, 0 bytes, 0 overruns
Received 0 broadcasts, 0 multicast, 0 unicast 0 runts, 0 giants, 0 jabbers 0 input errors,
0 CRC, 0 fragments, 0 pause input 0 packets output, 0 bytes, 0 underruns 0 broadcast, 0
multicast, 0 unicast 0 late collisions, 0 collisions, 0 deferred 0 bad bytes received, 0
multiple, 0 pause output
```

Upgrading the Cisco IOS Software

This module describes how to upgrade the Cisco Internet Operating System (IOS) software image on the following hardware:

- Cisco 3900 series ISRs
- Cisco 2900 series ISRs
- Cisco 1900 series ISRs
- Cisco 1941W Wireless Device

This module contains the following sections:

- Restrictions for Upgrading the System Image, page 213
- Information About Upgrading the System Image, page 214
- How to Upgrade the Cisco IOS Image, page 215
- How to Upgrade the IOS Image on the Access Point, page 235
- Additional References, page 238

Restrictions for Upgrading the System Image

- Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series integrated services routers (ISRs) download images to new Advanced Capability CompactFlash (CF) memory cards. Legacy CF will not operate in Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series ISRs. When legacy CF is inserted, the following error message appears:

  WARNING: *Unsupported compact flash detected. Use of this card during normal operation can impact and severely degrade performance of the system. Please use supported compact flash cards only.*

- Slot0 is the default CF slot. CF in Slot0 stores system image, configuration, and data files. CF must be present in this slot for the router to boot and perform normal file operations.
- Cisco IOS images for the access point download images to the CF embedded on the access point.

Table 1 describes the slot number and name for the Advanced Capability CF slots.

Table 1 Compact Flash Slot Numbering and Naming

Slot Number	CF Filenames
Slot0[1]	`flash0:`[2]
Slot1	`flash1:`

1. Slot 0 is the default CF slot. It stores the system image, configurations, and data files. CF must be present in this slot for the router to boot and perform normal file operations.
2. **flash0:** is aliased to **flash:**.

Table 2 describes the slot number and name for the USB slots.

Table 2 USB Slot Numbering and Naming

Slot Number	USB Filenames
Slot0	`usbflash0:`
Slot1	`usbflash1:`

Information About Upgrading the System Image

To upgrade the system image on your router review the following sections:

- Why Would I Upgrade the System Image?, page 214
- Which Cisco IOS Release Is Running on My Router Now?, page 215
- How Do I Choose the New Cisco IOS Release and Feature Set?, page 215
- Where Do I Download the System Image?, page 215

Why Would I Upgrade the System Image?

System images contain the Cisco IOS software. Your router was shipped with an image installed.

Note The Cisco 1941W access point runs a Cisco IOS image that is separate from the Cisco IOS image on the router.

At some point, you may want to load a different image onto the router or the access point. For example, you may want to upgrade your IOS software to the latest release, or you may want to use the same Cisco IOS release for all the routers in a network. Each system image contains different sets of Cisco IOS features, therefore select an appropriate system image to suit your network requirements.

Which Cisco IOS Release Is Running on My Router Now?

To determine the Cisco IOS release that is currently running on your router, and the filename of the system image, enter the **show version** command in user EXEC or privileged EXEC mode.

How Do I Choose the New Cisco IOS Release and Feature Set?

To determine which Cisco IOS releases and feature are supported on your platform, go to Cisco Feature Navigator at http://www.cisco.com/go/cfn. You must have an account at Cisco.com. If you do not have an account or have forgotten your username or password, click **Cancel** at the login dialog box and follow the instructions that appear.

Cisco 3900 series, 2900 series, and 1900 series ISRs support Cisco IOS software entitlement and enforcement. See *Software Activation on Cisco Integrated Services Routers* at Cisco.com for feature and package license information.

Where Do I Download the System Image?

To download a system image you must have an account at Cisco.com to gain access to the following websites. If you do not have an account or have forgotten your username or password, click **Cancel** at the login dialog box, and follow the instructions that appear.

If you know the Cisco IOS release and feature set you want to download, go directly to http://www.cisco.com/kobayashi/sw-center/index.shtml.

For more information before selecting the Cisco IOS release and feature set, go to the Software Download Center at:
http://www.cisco.com/public/sw-center/index.shtml.

For more information about Loading and Managing System images, go to
http://www.cisco.com/en/US/docs/ios/fundamentals/configuration/guide/cf_system_images.html.

How to Upgrade the Cisco IOS Image

This section provides information about upgrading the Cisco IOS image on the router.

- Saving Backup Copies of Your Old System Image and Configuration, page 216
- Ensuring Adequate DRAM for the New System Image, page 217
- Ensuring Adequate Flash Memory for the New System Image, page 219
- Copying the System Image into Flash Memory, page 222
- Loading the New System Image, page 228
- Saving Backup Copies of Your New System Image and Configuration, page 233

Saving Backup Copies of Your Old System Image and Configuration

To avoid unexpected downtime in the event you encounter serious problems using a new system image or startup configuration, we recommend that you save backup copies of your current startup configuration file and Cisco IOS software system image file on a server.

For more detailed information, see the "Managing Configuration Files" chapter and the "Loading and Maintaining System Images" chapter of *Cisco IOS Configuration Fundamentals Guide* at: http://www.cisco.com/en/US/docs/ios/fundamentals/configuration/guide/12_4t/cf_12_4t_book.html.

To save backup copies of the startup configuration file and the system image file, complete the following steps.

SUMMARY STEPS

1. **enable**
2. **copy nvram:startup-config** {**ftp:** | **rcp:** | **tftp:**}
3. **dir** {**flash0:** | **flash1:**}
4. **copy flash0:** {**ftp:** | **rcp:** | **tftp:**}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**copy nvram:startup-config** {**ftp:**	**rcp:**	**tftp:**} **Example:** `Router# copy nvram:startup-config ftp:`	Copies the startup configuration file to a server. • The configuration file copy can serve as a backup copy. • Enter the destination URL when prompted.
Step 3	**dir flash0:** **Example:** `Router# dir flash0:`	Displays the layout and contents of a flash memory file system. **flash0:** is aliased onto **flash:**. • Learn the name of the system image file.
Step 4	**copy flash0:** {**ftp:**	**rcp:**	**tftp:**} **Example:** `Router# copy flash0: ftp:`	Copies a file from flash memory to a server. • Copy the system image file to a server. This file can serve as a backup copy. • Enter the flash memory partition number if prompted. • Enter the filename and destination URL when prompted.

Examples

The following examples show how to copy a startup configuration to a TFTP server and how to copy from flash memory to an FTP server.

Copying the Startup Configuration to a TFTP Server: Example

The following example shows the startup configuration being copied to a TFTP server:

```
Router# copy nvram:startup-config tftp:

Remote host[]? 192.0.0.1

Name of configuration file to write [rtr2-confg]? rtr2-config-b4upgrade
Write file rtr2-confg-b4upgrade on host 192.0.0.1?[confirm] <cr>
![OK]
```

Copying from Flash Memory to a TFTP Server: Example

The following example uses the **dir flash0:** command in privileged EXEC mode to learn the name of the system image file and the **copy flash0: tftp:** command in privileged EXEC mode to copy the system image to a TFTP server. The router uses the default username and password.

```
Router# copy flash0: tftp:
Source filename [running-config]?
Address or name of remote host []? 192.0.0.1
Destination filename [router-confg]? running-config
983 bytes copied in 0.048 secs (20479 bytes/sec)

Router#
Router# dir flash0:
Directory of flash0:/

    1  -rw-    48311224   Mar 2 1901 11:32:50 +00:00
c3900-universalk9-mz.SSA.XFR_20090407
    2  -rw-      185667  Jan 27 2021 09:03:54 +00:00  crashinfo_20210127-090354
    3  -rw-         983  Feb 14 2021 12:41:52 +00:00  running-config

260173824 bytes total (211668992 bytes free)
Router#
```

Ensuring Adequate DRAM for the New System Image

This section describes how to check whether your router has enough DRAM for upgrading to the new system image.

Prerequisites

Choose the Cisco IOS release and system image to which you want to upgrade. See the "Information About Upgrading the System Image" section on page 214.

SUMMARY STEPS

1. Select the system image in the Cisco IOS Upgrade Planner at:

   http://www.cisco.com/cgi-bin/Software/Iosplanner/Planner-tool/iosplanner.cgi.
2. Write down the minimum memory requirements for the image, as displayed in the File Download Information table.
3. **show version**
4. Add the memory sizes that are displayed in the **show version** command output to calculate your router's DRAM size.
5. Compare the calculated DRAM size with the minimum memory requirements from Step 2.
   a. If the DRAM is equal to or greater than the new system image's minimum memory requirements, proceed to the "Ensuring Adequate Flash Memory for the New System Image" section on page 219.
   b. If the DRAM is less than the new system image's minimum flash requirements, you must upgrade your DRAM. See the hardware installation guide for your router.

DETAILED STEPS

Step 1 Select the system image in the Cisco IOS Upgrade Planner at:

http://www.cisco.com/cgi-bin/Software/Iosplanner/Planner-tool/iosplanner.cgi.

You must have an account at Cisco.com. If you do not have an account or have forgotten your username or password, click Cancel at the login dialog box and follow the instructions that appear.

Step 2 Write down the minimum memory requirements for the image, as displayed in the File Download Information table.

Step 3 Use the **show version** command to display the router processor and memory.

Step 4 Add the memory sizes to calculate the amount of DRAM in your router.

For example, if your memory sizes are 231424 KB and 30720 KB for a total of 262144 KB, it would be 256 MB of DRAM.

Tip To convert from kilobytes (KB) to megabytes (MB), divide the number of kilobytes by 1024.

Step 5 Compare the amount of DRAM in the router to the minimum memory requirements from Step 2.

a. If the DRAM is equal to or greater than the new system image's minimum memory requirements, proceed to the "Ensuring Adequate Flash Memory for the New System Image" section on page 219.

b. If the DRAM is less than the new system image's minimum memory requirements, you must upgrade your DRAM. See the hardware installation guide for your router.

Ensuring Adequate Flash Memory for the New System Image

This section describes how to check whether your router has enough flash memory to upgrade to the new system image and, if necessary, how to properly delete files in flash memory to make room for the new system image.

Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series ISRs have two external CF slots and two USB slots. Use the secondary CF for overflow files, if required. Table 3 lists CF slot number, name, and size.

Table 3 Compact Flash Slot Number, Name, and Size

Slot Number	CF Filename	Size[1]
Slot0[2]	`flash0:`	`256MB`
Slot1	`flash1:`	`0`

1. The maximum storage capacity for the CF in Slot0 and Slot1 is 4GB.
2. Slot0 is the default CF slot. CF in Slot0 stores system image, configuration, and data files. CF must be present in this slot for the router to boot and perform normal file operations.

Table 4 lists the USB slot number, name, and size.

Table 4 USB Slot Number, Name, and Size

Slot Number	USB Filename	Size[1]
Slot0	`usbflash0:`	`64MB`
Slot1	`usbflash1:`	`0`

1. The maximum storage capacity for the USB in Slot0 and Slot1 is 4GB.

Prerequisites

In order to check whether your router has enough flash memory for a new system image, you need to obtain the image's flash requirements from Cisco:

- Choose the Cisco IOS release and system image to which you want to upgrade. See the "Information About Upgrading the System Image" section on page 214.
- Select the system image in the Cisco IOS Upgrade Planner at:

  http://www.cisco.com/cgi-bin/Software/Iosplanner/Planner-tool/iosplanner.cgi.

  You must have an account at Cisco.com. If you do not have an account or have forgotten your username or password, click Cancel at the login dialog box and follow the instructions that appear.

  From the File Download Information table, write down the minimum flash requirements for the image.

SUMMARY STEPS

1. **enable**
2. **dir flash0:**
3. From the displayed output of the **dir flash0:** command, compare the number of bytes *available* to the minimum flash requirements for the new system image.
   a. If the available memory is equal to or greater than the new system image's minimum flash requirements, proceed to the "Copying the System Image into Flash Memory" section on page 222.
   b. If the available memory is less than the new system image's minimum flash requirements, proceed to Step 4.
4. From the displayed output of the **dir flash0:** command, compare the number of bytes *total* to the size of the system image to which you want to upgrade.
   a. If the total memory is less than the new system image's minimum flash requirements, you must upgrade your compact flash memory card. See the hardware installation guide for your router.
   b. If the total memory is equal to or greater than the new system image's minimum flash requirements, proceed to Step 5.
5. **dir /all flash0:**
6. From the displayed output of the **dir /all flash0:** command, write down the names and directory locations of the files that you can delete.
7. (Optional) **copy flash0:** {**tftp** | **rcp**}
8. (Optional) Repeat Step 7 for each file that you identified in Step 6.
9. **delete flash0:***directory-path*/*filename*
10. Repeat Step 9 for each file that you identified in Step 6.
11. **dir flash0:**[*partition-number***:**]
12. From the displayed output of the **dir flash0:** command, compare the number of bytes *available* to the size of the system image to which you want to upgrade.
    a. If the available memory is less than the new system image's minimum flash requirements, then you must upgrade your compact flash memory card to a size that can accommodate both the existing files and the new system image. See the hardware installation guide for your router.
    b. If the available memory is equal to or greater than the new system image's minimum flash requirements, proceed to the "Copying the System Image into Flash Memory" section on page 222.

DETAILED STEPS

Step 1 **enable**

Use this command to enter privileged EXEC mode. Enter your password if prompted. For example:

```
Router> enable
Password:
Router#
```

Step 2 **dir flash0:**

Use this command to display the layout and contents of flash memory:

```
Router# dir flash0:

Flash CompactFlash directory:
File  Length   Name/status
   1   6458208  c39xx.tmp [deleted]
   2   6458208  c39xxmz
[12916544 bytes used, 3139776 available, 16056320 total]
15680K bytes of ATA CompactFlash (Read/Write)
```

Step 3 From the displayed output of the **dir flash0:** command, compare the number of bytes *available* to the minimum flash requirements for the new system image.

- If the available memory is equal to or greater than the new system image's minimum flash requirements, proceed to the "Copying the System Image into Flash Memory" section on page 222.
- If the available memory is less than the new system image's minimum flash requirements, proceed to Step 4.

Step 4 From the displayed output of the **dir flash0:** command, compare the number of bytes *total* to the size of the system image to which you want to upgrade.

- If the total memory is less than the new system image's minimum flash requirements, you must upgrade your compact flash memory card. See the hardware installation guide for your router.
- If the total memory is equal to or greater than the new system image's minimum flash requirements, proceed to Step 5.

Step 5 **dir /all flash0:**

Use this command to display a list of all files and directories in flash memory:

```
Router# dir /all flash0:

Directory of flash:/

    3  -rw-     6458388   Mar 01 1993 00:00:58  c39xx.tmp
 1580  -rw-     6462268   Mar 06 1993 06:14:02  c39xx-ata

63930368 bytes total (51007488 bytes free)
```

Step 6 From the displayed output of the **dir /all flash0:** command, write down the names and directory locations of the files that you can delete. If you cannot delete any files, you must upgrade your compact flash memory card. See the hardware installation guide for your router.

Note Do not delete the system image that the router already uses. If you are not sure which files can be safely deleted, either consult your network administrator or upgrade your compact flash memory card to a size that can accommodate both the existing files and the new system image. See the hardware installation guide for your router.

Step 7 **copy flash0:{tftp | rcp}**

(Optional) Copy a file to a server before deleting the file from flash memory. When prompted, enter the filename and the server's hostname or IP address:

```
Router# copy flash0: tftp
```

Step 8 (Optional) Repeat Step 7 for each file that you identified in Step 6.

Step 9 **delete flash0:***directory-path/filename*

Use this command to delete a file in flash memory:

```
Router# delete flash0:c39xx.tmp

Delete filename [c39xx.tmp]? <cr>
Delete flash0:c39xx.tmp? [confirm] <cr>
```

Step 10 Repeat Step 9 for each file that you identified in Step 6.

Step 11 **dir flash0:**

Use this command to display the layout and contents of flash memory:

```
Router# dir flash0:

Flash CompactFlash directory:
File  Length   Name/status
   1   6458208  c39xx.tmp [deleted]
   2   6458208  c3xx-mz
[12916544 bytes used, 3139776 available, 16056320 total]
15680K bytes of ATA CompactFlash (Read/Write)
```

Step 12 From the displayed output of the **dir flash0:** command, compare the number of bytes *available* to the size of the system image to which you want to upgrade.

- If the available memory is less than the new system image's minimum flash requirements, you must upgrade your compact flash memory card to a size that can accommodate both the existing files and the new system image. See the hardware installation guide for your router.
- If the available memory is equal to or greater than the new system image's minimum flash requirements, proceed to the "Copying the System Image into Flash Memory" section on page 222.

What to Do Next

Proceed to the "Copying the System Image into Flash Memory" section on page 222.

Copying the System Image into Flash Memory

This section describes how to copy the system image into the compact flash memory card for your router. Choose one of the following methods:

- Using TFTP or Remote Copy Protocol to Copy the System Image into Flash Memory, page 223
- Using the ROM Monitor to Copy the System Image over a Network, page 225
- Using a PC with a CompactFlash Card Reader to Copy the System Image into Flash Memory, page 227

Using TFTP or Remote Copy Protocol to Copy the System Image into Flash Memory

This section describes how to use TFTP or Remote Copy Protocol (RCP) to upgrade the system image. This is the recommended and most common method of upgrading the system image.

Prerequisites

The following details the logistics of upgrading the system image.

- Install a TFTP server or an RCP server application on a TCP/IP-ready workstation or PC. Many third-party vendors provide free TFTP server software, which you can find by searching for "TFTP server" in a web search engine.

  If you use TFTP:

  - Configure the TFTP application to operate as a TFTP *server*, not a TFTP *client*.
  - Specify the outbound file directory to which you will download and store the system image.
- Download the new Cisco IOS software image into the workstation or PC. See the "Where Do I Download the System Image?" section on page 215.
- Establish a console session to the router. We recommend that you connect your PC directly to the router console port. See the hardware installation guide for your router.
- Verify that the TFTP or RCP server has IP connectivity to the router. If you cannot successfully ping between the TFTP or RCP server and the router, do one of the following:
  - Configure a default gateway on the router.
  - Make sure that the server and the router each have an IP address in the same network or subnet. See the *Determining IP Addresses: Frequently Asked Questions* tech note.

Tip For more detailed information on how to perform the prerequisites, see the *Software Installation and Upgrade Procedure* tech note.

SUMMARY STEPS

1. **enable**
2. **copy tftp flash0:**
   or
   copy rcp flash0:
3. When prompted, enter the IP address of the TFTP or RCP server.
4. When prompted, enter the filename of the Cisco IOS software image to be installed.
5. When prompted, enter the filename as you want it to appear on the router.
6. If an error message appears that says, "Not enough space on device," do one of the following, as appropriate:

- If you are certain that all the files in flash memory should be erased, enter **y** twice when prompted to erase flash before copying.
- If you are *not* certain that all files in flash memory should be erased, press **Ctrl-Z** and follow the instructions in the "Ensuring Adequate Flash Memory for the New System Image" section on page 219.

7. If the error message does not appear, enter **no** when prompted to erase the flash memory before copying.

DETAILED STEPS

Step 1 **enable**

Use this command to enter privileged EXEC mode. Enter your password if prompted:

```
Router> enable
Password: <password>
Router#
```

Step 2 **copy tftp flash0:**

or

copy rcp flash0

Use one of these commands to copy a file from a server to flash memory:

```
Router# copy tftp flash0:
```

Step 3 When prompted, enter the IP address of the TFTP or RCP server:

```
Address or name of remote host []? 10.10.10.2
```

Step 4 When prompted, enter the filename of the Cisco IOS software image to be installed:

```
Source filename []? c2900-universalk9-mz.bin
```

Note The filename is case sensitive.

Step 5 When prompted, enter the filename as you want it to appear on the router. Typically, the same filename is entered as was used in Step 4:

```
Destination filename []? c2900-universalk9-mz.bin
```

Step 6 If an error message appears that says, "Not enough space on device," do one of the following as appropriate:

- If you are certain that all the files in flash memory should be erased, enter **y** when prompted twice to confirm that flash memory will be erased before copying:

```
Accessing tftp://10.10.10.2/c2900-universalk9-mz.bin...
     Erase flash0: before copying? [confirm] y
     Erasing the flash filesystem will remove all files! Continue? [confirm] y
     Erasing device... eeee
```

What to Do Next

Proceed to the "Loading the New System Image" section on page 228.

Using the ROM Monitor to Copy the System Image over a Network

This section describes how to download a Cisco IOS software image from a remote TFTP server to the router flash memory by using the **tftpdnld** ROM monitor command.

Caution Using the **tftpdnld** ROM monitor command may erase the system image, configuration, and data files. System image, configuration, and data files must be present on USB CF in slot0 for the router to boot and perform normal file operations.

Before you can enter the **tftpdnld** ROM monitor command, you must set the ROM monitor environment variables.

Prerequisites

Connect the TFTP server to a fixed network port on your router.

Restrictions

The LAN ports on network modules or interface cards are not active in ROM monitor mode. Therefore, only a fixed port on your router can be used for TFTP download. This can be either a fixed Ethernet port on the router or one of the Gigabit Ethernet ports on routers equipped with them.

Note You can use this command only to download files to the router. You cannot use **tftpdnld** to get files from the router.

SUMMARY STEPS

1. Enter ROM monitor mode
2. Set the IP_ADDRESS=ip_address configuration variable.
3. Set the IP_SUBNET_MASK=ip_address configuration variable.
4. Set the DEFAULT_GATEWAY=ip_address configuration variable.
5. Set the TFTP_SERVER=ip_address configuration variable.
6. Set the TFTP_FILE=[directory-path/]filename configuration variable.
7. (Optional) Set the GE_PORT=[0 | 1| 2 | 3] port number for download.
8. (Optional) Set the TFTP_MEDIA_TYPE=[0 | 1] copper or fiber.
9. (Optional) Set the TFTP_MACADDR= mac address of unit.
10. (Optional) Set the TFTP_VERBOSE= [0 | 1| 2] print setting variable.
11. (Optional) Set the TFTP_RETRY_COUNT=retry_times configuration variable.
12. (Optional) Set the TFTP_TIMEOUT=timeout of operation in seconds.
13. (Optional) Set the TFTP_ACK_RETRY=ack retry in seconds.
14. (Optional) Set the TFTP_CHECKSUM=[0 | 1] perform checksum test on image.

15. (Optional) Set the TFTP_DESTINATION=[flash0: | flash1: | usbflash0: | usbflash1:] flash destination device for file.
16. (Optional) Set the GE_SPEED_MODE= speed configuration.
17. Use the **set** command to verify that you have set the variables correctly.
18. Use the **tftpdnld [-r]** command to download the image.

DETAILED STEPS

Step 1 Enter ROM monitor mode.

Step 2 Set the IP address of the router. For example:

```
rommon > IP_ADDRESS=172.16.23.32
```

Step 3 Set the IP subnet mask. For example:

```
rommon > IP_SUBNET_MASK=255.255.255.224
```

Step 4 Set the default gateway address. For example:

```
rommon > DEFAULT_GATEWAY=172.16.23.40
```

Step 5 Set the TFTP server IP address, which is the location from which the software will be downloaded:

```
rommon > TFTP_SERVER=172.16.23.33
```

Step 6 Set the name and directory location to which the image file will be downloaded onto the router. For example:

```
rommon > TFTP_FILE=archive/rel22/<image name>
```

Step 7 (Optional) Set the input port to use a Gigabit Ethernet port. Usage is GE_PORT=[0 | 1 | 2]. For example:

```
rommon > GE_PORT=0
```

Step 8 (Optional) Set the Ethernet media type. Usage is TFTP_ MEDIA_TYPE=[0 1], where Copper= 0 and Fiber=1:

```
rommon > TFTP_MEDIA_TYPE=1
```

Step 9 (Optional) Decide whether the router will perform a checksum test on the downloaded image. Usage is TFTP_CHECKSUM=[0 | 1], where 1=checksum test is performed (default) and 0=no checksum test. For example:

```
rommon > TFTP_CHECKSUM=0
```

Step 10 (Optional) Set the number of times that the router will attempt Address Resolution Protocol (ARP) and TFTP download. The default is 7 attempts. For example:

```
rommon > TFTP_RETRY_COUNT=10
```

Step 11 (Optional) Set the amount of time, in seconds, before the download process times out. The default is 2400 seconds (40 minutes). The following example shows 1800 seconds (30 minutes):

```
TFTP_TIMEOUT=1800
```

Step 12 (Optional) Configure the print variable. Usage is TFTP_VERBOSE= [0 | 1 | 2], where print:

0= is quiet.

1= in progress.

2= verbose

Step 13 Use the **set** command to display the ROM monitor environment variables to verify that you have configured them correctly. For example:

```
rommon > set
```

Step 14 Download the system image, as specified by the ROM monitor environmental variables, using the **tftpdnld [-r]** command. Without the **-r** option, the command downloads the specified image and saves it in flash memory, deleting all existing data in all partitions in flash memory. Using the **-r** option downloads and boots the new software but does not save the software to flash memory.

```
rommon> tftpdnld [-r]
A prompt is displayed:
Do you wish to continue? y/n:  [n]:  y
```

Entering **y** confirms that you want to continue with the TFTP download.

What to Do Next

Proceed to the "Loading the New System Image" section on page 228.

Using a PC with a CompactFlash Card Reader to Copy the System Image into Flash Memory

Because the system image is stored on an external CompactFlash memory card, you can use a PC with a compact flash card reader to format the card and copy a new system image file onto the card. However, this upgrade method is not commonly used.

For more information about using flash memory cards, see Appendix B, "Using CompactFlash Memory Cards."

Prerequisites

- Download the new Cisco IOS Software image to the PC. See the "Where Do I Download the System Image?" section on page 215.
- Locate the compact flash memory card slot on the router chassis. For help with locating the slot and instructions for removing and inserting the card, see the hardware installation guide for your router.

Caution Removing the compact flash memory card may disrupt the network because some software features use the compact flash memory card to store tables and other important data.

DETAILED STEPS

Step 1 Remove the compact flash memory card from the router.

Step 2 Insert the card into the compact flash card reader on a PC.

Step 3 Use the PC to copy the system image file to the compact flash memory card.

Step 4 Remove the card from the compact flash card reader.

Step 5 Insert the compact flash memory card into the router.

What to Do Next

Proceed to the "Loading the New System Image" section on page 228.

Loading the New System Image

This section describes how to load the new system image that you copied into flash memory. First, determine whether you are in ROM monitor mode or in the Cisco IOS CLI, then choose one of the following methods of loading the new system image:

- Loading the New System Image from the Cisco IOS Software, page 228
- Loading the New System Image from ROM Monitor Mode, page 231

Loading the New System Image from the Cisco IOS Software

To load the new system image from the Cisco IOS software, follow these steps.

SUMMARY STEPS

1. **dir flash0:**
2. **configure terminal**
3. **no boot system**
4. (Optional) **boot system flash0:** *system-image-filename*
5. (Optional) Repeat to specify the order in which the router should attempt to load any backup system images.
6. **exit**
7. **show version**
8. If the last digit in the configuration register is 0 or 1, proceed to Step 9. However, if the last digit in the configuration register is between 2 and F, proceed to Step 12.
9. **configure terminal**
10. **config-register 0x2102**
11. **exit**
12. **copy run start**
13. **reload**

14. When prompted to save the system configuration, enter **no**.
15. When prompted to confirm the reload, enter **y**.
16. **show version**

DETAILED STEPS

Step 1 **dir flash0:**

Use this command to display a list of all files and directories in flash memory:

```
Router# dir flash0:

Directory of flash0:/

    3  -rw-     6458388   Mar 01 1993 00:00:58  c38xx.tmp
 1580  -rw-     6462268   Mar 06 1993 06:14:02  c38xx-ata

63930368 bytes total (51007488 bytes free)
```

Note Determine whether the new system image is the first file or the only file listed in the **dir flash0:** command output (is not required if it is the first file or only file listed).

Step 2 **configure terminal**

Use this command to enter global configuration mode:

```
Router# configure terminal

Router(config)#
```

Step 3 **no boot system**

Use this command to delete all entries in the bootable image list, which specifies the order in which the router attempts to load the system images at the next system reload or power cycle:

```
Router(config)# no boot system
```

Step 4 If the new system image is the first file or the only file displayed in the **dir flash0:** command output, you do not need to perform the following step.

boot system flash0: *system-image-filename*

Use this command to load the new system image after the next system reload or power cycle. For example:

```
Router(config)# boot system flash0: c2900-universalk9-mz.bin
```

Step 5 (Optional) Repeat to specify the order in which the router should attempt to load any backup system images.

Step 6 **exit**

Use this command to exit global configuration mode:

```
Router(config)# exit
Router#
```

Step 7 **show version**

Use this command to display the configuration register setting:

```
Router# show version

Cisco Internetwork Operating System Software
.
.
.
Configuration register is 0x0

Router#
```

Step 8 If the last digit in the configuration register is 0 or 1, proceed to Step 9. However, if the last digit in the configuration register is between 2 and F, proceed to Step 12.

Step 9 **configure terminal**

Use this command to enter global configuration mode:

```
Router# configure terminal

Router(config)#
```

Step 10 **config-register 0x2102**

Use this command to set the configuration register so that, after the next system reload or power cycle, the router loads a system image from the **boot system** commands in the startup configuration file:

```
Router(config)# config-register 0x2102
```

Step 11 **exit**

Use this command to exit global configuration mode:

```
Router(config)# exit
Router#
```

Step 12 **copy run start**

Use this command to copy the running configuration to the startup configuration:

```
Router# copy run start
```

Step 13 **reload**

Use this command to reload the operating system:

```
Router# reload
```

Step 14 When prompted to save the system configuration, enter **no**:

```
System configuration has been modified. Save? [yes/no]: no
```

Step 15 When prompted to confirm the reload, enter **y**:

```
Proceed with reload? [confirm] y
```

Step 16 **show version**

Use this command to verify that the router loaded the proper system image:

```
Router# show version

00:22:25: %SYS-5-CONFIG_I: Configured from console by console
Cisco Internetwork Operating System Software
.
.
.
System returned to ROM by reload
System image file is "flash0:c2900-universalk9-mz.bin"
```

What to Do Next

Proceed to the "Saving Backup Copies of Your New System Image and Configuration" section on page 233.

Loading the New System Image from ROM Monitor Mode

To load the new system image from ROM monitor mode, follow these steps.

SUMMARY STEPS

1. **dir flash0:**[*partition-number***:**]
2. **confreg 0x2102**
3. **boot flash0:**[*partition-number***:**]*filename*
4. After the system loads the new system image, press **Return** a few times to display the Cisco IOS command-line interface (CLI) prompt.
5. **enable**
6. **configure terminal**
7. **no boot system**
8. **boot system flash0:** *new-system-image-filename*
9. (Optional) Repeat to specify the order in which the router should attempt to load any backup system images.
10. **exit**
11. **copy run start**

DETAILED STEPS

Step 1 **dir flash0:**[*partition-number*:]

Use this command to list files in flash memory:

```
rommon > dir flash0:

program load complete, entry point: 0x4000000, size: 0x18fa0
Directory of flash0:

2      48296872  -rw-     c3900-universalk9-mz.SPA
```

Note whether the new system image is the first file or the only file listed in the **dir flash0:** command output.

Step 2 **confreg 0x2102**

Use this command to set the configuration register so that, after the next system reload or power cycle, the router loads a system image from the **boot system** commands in the startup configuration file:

```
rommon > confreg 0x2102
```

Step 3 **boot flash0:**[*partition-number*:]*filename*

Use this command to force the router to load the new system image:

```
rommon > boot flash0:c2900-universalk9-mz.binT
```

Step 4 After the system loads the new system image, press **Return** a few times to display the Cisco IOS CLI prompt.

Step 5 **enable**

Use this command to enable privileged EXEC mode, and enter your password if prompted:

```
Router> enable
Password: <password>
Router#
```

Step 6 **configure terminal**

Use this command to enter global configuration mode:

```
Router# configure terminal
Router(config)#
```

Step 7 **no boot system**

Eliminate all entries in the bootable image list, which specifies the system image that the router loads at startup:

```
Router(config)# no boot system
```

Step 8 If the new system image is the first file or only the file displayed in the **dir flash0:** command output, this step is not required.

boot system flash0: *new-system-image-filename*

Use this command to load the new system image after the next system reload or power cycle:

```
Router(config)# boot system flash0: c2900-universalk9-mz.bin
```

Step 9 (Optional) Repeat to specify the order in which the router should attempt to load any backup system images.

Step 10 **exit**

Use this command to exit global configuration mode:

```
Router(config)# exit
Router#
```

Step 11 **copy run start**

Use this command to copy the running configuration to the startup configuration:

```
Router# copy run start
```

What to Do Next

Proceed to the "Saving Backup Copies of Your New System Image and Configuration" section on page 233.

Saving Backup Copies of Your New System Image and Configuration

To aid file recovery and to minimize downtime in the event of file corruption, we recommend that you save backup copies of the startup configuration file and the Cisco IOS software system image file on a server.

Tip Do not erase any existing backup copies of your configuration and system image that you saved before upgrading your system image. If you encounter serious problems using your new system image or startup configuration, you can quickly revert to the previous working configuration and system image.

For more detailed information, see the "Managing Configuration Files" chapter and the "Loading and Maintaining System Images" chapter of the *Cisco IOS Configuration Fundamentals Configuration Guide* at:
http://www.cisco.com/en/US/docs/ios/fundamentals/configuration/guide/12_4/cf_12_4_book.html.

To save backup copies of the startup configuration file and the system image file, complete the following steps.

SUMMARY STEPS

1. **enable**
2. **copy nvram:startup-config** {**ftp:** | **rcp:** | **tftp:**}
3. **dir flash0:**
4. **copy flash0:** {**ftp:** | **rcp:** | **tftp:**}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**copy nvram:startup-config** {**ftp:** | **rcp:** | **tftp:**} **Example:** `Router# copy nvram:startup-config ftp:`	Copies the startup configuration file to a server. • The configuration file copy serves as a backup copy. • Enter the destination URL when prompted.
Step 3	**dir flash0:** **Example:** `Router# dir flash0:`	Displays the layout and contents of a flash memory file system. • Write down the name of the system image file.
Step 4	**copy flash0:** {**ftp:** | **rcp:** | **tftp:**} **Example:** `Router# copy flash0: ftp:`	Copies a file from flash memory to a server. • Copy the system image file to a server to serve as a backup copy. • Enter the flash memory partition number if prompted. • Enter the filename and destination URL when prompted.

Examples

Copying the Startup Configuration to a TFTP Server: Example

The following example shows the startup configuration being copied to a TFTP server:

```
Router# copy nvram:startup-config tftp:

Remote host[]? 172.16.101.101

Name of configuration file to write [rtr2-confg]? <cr>
Write file rtr2-confg on host 172.16.101.101?[confirm] <cr>
![OK]
```

Copying from Flash Memory to a TFTP Server: Example

The following example uses the **dir flash0:** privileged EXEC command to obtain the name of the system image file and the **copy flash0: tftp:** privileged EXEC command to copy the system image to a TFTP server. The router uses the default username and password.

```
Router# dir flash0:

System flash directory:
File Length Name/status
1 4137888 c2900-mz
[4137952 bytes used, 12639264 available, 16777216 total]
16384K bytes of processor board System flash (Read/Write)\
```

```
Router# copy flash0: tftp:
IP address of remote host [255.255.255.255]? 192.0.0.1
filename to write on tftp host? c2900-universalk9-mz
writing c2900-mz !!!!...
successful ftp write.
```

How to Upgrade the IOS Image on the Access Point

This section describes how to upgrade the Cisco IOS image on the access point.

To upgrade the IOS image on the access point, establish connectivity between the access point and the download server by following these steps:

- Define the WAN Interface on the Router, page 235
- Secure an IP Address on the Access Point, page 236
- Confirm Connectivity and Settings, page 236
- Upgrading the IOS Image on the Access Point, page 237

Define the WAN Interface on the Router

To define a WAN interface to connect to a TFTP network for image download, follow these steps, beginning in global configuration mode.

SUMMARY STEPS

1. **interface gigabitethernet** *slot/port*
2. **ip address** *ip-address mask*
3. **no shutdown**
4. **exit**

DETAILED STEPS

	Command	Purpose

Step 1	**interface gigabitethernet** *slot/port*
	
	Example:
	`Router(config)# interface gigabitethernet 0/0`
	`Router(config-if)#`
		Enters the configuration mode for a Gigabit Ethernet interface on the router.

Step 2	**ip address** *ip-address mask*
	
	Example:
	`Router(config-if)# ip address 192.168.12.2 255.255.255.0`
	`Router(config-if)#`
		Sets the IP address and subnet mask for the specified Gigabit Ethernet interface.

	Command	Purpose

Step 3	**no shutdown**
	
	Example:
	`Router(config-if)# no shutdown`
	`Router(config-if)#`
		Enables the Gigabit Ethernet interface, changing its state from administratively down to administratively up.

Step 4	**exit**
	
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits configuration mode for the Gigabit Ethernet interface and returns to global configuration mode.

Secure an IP Address on the Access Point

To secure an IP address on the access point so it can communicate with an external server where a Cisco IOS image is located, use the DHCP server functionality on the router. The host router provides the access point DHCP server functionality through the DHCP pool. The access point communicates with the external server and setup option 43 for the controller IP address in the DHCP pool configuration.

Example

The following example shows a dhcp pool configuration:

```
ip dhcp pool embedded-ap-pool
network 192.168.10.0 255.255.255.0
dns-server 171.70.168.183
default-router 192.168.10.1
int vlan1
ip address 192.168.10.0 255.255.255.0
```

Confirm Connectivity and Settings

Perform the following steps to confirm connectivity.

1. Ping the external server from the router to confirm connectivity.
2. Enter the **service-module wlan-ap 0 session** command to establish a session into the access point. For instructions, see "Starting a Wireless Configuration Session" section on page 243.
3. Ping the external server from the access point to confirm connectivity.

The following example shows a sample router and access point configuration:

Example

```
interface Wlan-GigabitEthernet0/0
!
interface GigabitEthernet0/0
 ip address dhcp
 duplex auto
 speed auto
!
interface wlan-ap0
```

```
 description Service module interface to manage the embedded AP
 ip address 10.0.0.1 255.0.0.0
 arp timeout 0
!
interface GigabitEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Vlan1
 ip address 192.168.10.1 255.255.255.0
!
ip forward-protocol nd
ip route 0.0.0.0 0.0.0.0 GigabitEthernet0/0
!
no ip http server
```

Upgrading the IOS Image on the Access Point

Follow the image upgrade instructions at Cisco.com using the IOS CLI, http://www.cisco.com/en/US/docs/wireless/access_point/12.3_8_JA/configuration/guide/s38mfw.html#wp1035609.

Note If the access point enters Bootloader mode, manually configure the IP address, default router, netmask, and default gateway to upgrade the IOS image.

Note The IP address must be assigned to the same subnet as the VLAN1 interface on the router. Here is an example configuration.

Example

ap: set

CONTROLLER_TYPE=0x05A4

DEFAULT_ROUTER=192.168.10.1

ENABLE_BREAK=yes

IOS_STATIC_DEFAULT_GATEWAY=192.168.10.1

IP_ADDR=192.168.10.2

MANUAL_BOOT=yes

NETMASK=255.255.255.0

PEP_PRODUCT_ID=AP801AGN-A-K9

PRODUCT_MODEL_NUM=AP801AGN-A-K9

TOP_ASSY_SERIAL_NUM=FHKTESTTEST

ap: copy tftp://223.255.254.254/saek/ap801-k9w7-tar.124-10b.JDA flash0:
ap801-k9w7-tar.124-10b.JDA

Additional References

The following sections provide references related to upgrading the system image on your router.

Related Documents and Websites

Related Topic	Document Title or Website
Matching Cisco IOS releases and features to hardware	Cisco Feature Navigator http://www.cisco.com/go/fn
Downloading system images Displaying minimum DRAM and flash memory requirements	Cisco IOS Upgrade Planner http://www.cisco.com/cgi-bin/Software/Iosplanner/Planner-tool/iosplanner.cgi
Choosing and downloading system images	Software Download Center http://www.cisco.com/kobayashi/sw-center/index.shtml
Loading and maintaining system images	http://www.cisco.com/en/US/docs/ios/fundamentals/configuration/guide/cf_system_images.html
Removing, inserting, and upgrading compact flash memory cards	Hardware installation guide for your router
Connecting your PC to the router console port	Hardware installation guide for your router

Technical Assistance

Description	Link
Technical Assistance Center (TAC) home page, containing 30,000 pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.[1]	http://www.cisco.com/public/support/tac/home.shtml

1. You must have an account at Cisco.com. If you do not have an account or have forgotten your username or password, click Cancel at the login dialog box and follow the instructions that appear.

Wireless Device Overview

Wireless devices (also known as *access points*) 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. When configured as an access point, the wireless device serves as the connection point between wireless and wired networks or as the center point of a stand-alone wireless network. In large installations, wireless users within radio range of an access point can roam throughout a facility while maintaining seamless, uninterrupted access to the network.

With a management system based on Cisco IOS software, wireless devices are Wi-Fi CERTIFIED™, 802.11a-compliant, 802.11b-compliant, 802.11g-compliant, and 802.11n-compliant wireless LAN transceivers.

This module contains the following information:

- Software Modes, page 239
- Management Options, page 240

Software Modes

The access point is shipped on the Cisco 1941W integrated services router, and it includes an autonomous image and recovery image on the access point's flash. The default mode is autonomous, however the access point can be upgraded to operate in Cisco Unified Wireless mode.

Each mode is described below:

- **Autonomous mode**—Supports standalone network configurations, where all configuration settings are maintained locally on the wireless device. Each autonomous device can load its starting configuration independently, and still operate in a cohesive fashion on the network.
- **Cisco Unified Wireless mode**—Operates in conjunction with a Cisco Unified Wireless LAN controller, where all configuration information is maintained within the controller. In the Cisco Unified Wireless LAN architecture, wireless devices operate in the lightweight mode using Lightweight Access Point Protocol (LWAPP), (as opposed to autonomous mode). The lightweight access point, or wireless device, has no configuration until it associates to a controller. The configuration on the wireless device can be modified by the controller only when the networking is up and running. The controller manages the wireless device configuration, firmware, and control transactions such as 802.1x authentication. All wireless traffic is tunneled through the controller.

See *Why Migrate to a Cisco Unified Wireless Network?* at Cisco.com for more about this network architecture design:
http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps6521/product_at_a_glance0900aecd805df476.pdf

Management Options

The wireless device runs its own version of Cisco IOS software that is separate from the Cisco IOS software operating on the router. You can configure and monitor the access point with several different tools:

- Cisco IOS software command-line interface (CLI)
- Simple Network Management Protocol (SNMP)
- Web-browser interface
  http://cisco.com/en/US/docs/wireless/access_point/12.4_10b_JA/configuration/guide/scg12410b-chap2-gui.html

Note The web-browser interface is fully compatible with Microsoft Internet Explorer version 6.0 on Windows 98, 2000, and XP platforms, and with Netscape version 7.0 on Windows 98, 2000, XP, and Solaris platforms.

Note Avoid using the CLI and the web-browser tools concurrently when configuring the wireless device. If you configure the wireless device using the CLI, the web-browser interface may display an inaccurate interpretation of the configuration. This inappropriate display of information does not necessarily mean the wireless device is not configured properly.

Use the **interface dot11radio** command in global CLI configuration to place the wireless device into the radio configuration mode.

Network Configuration Examples

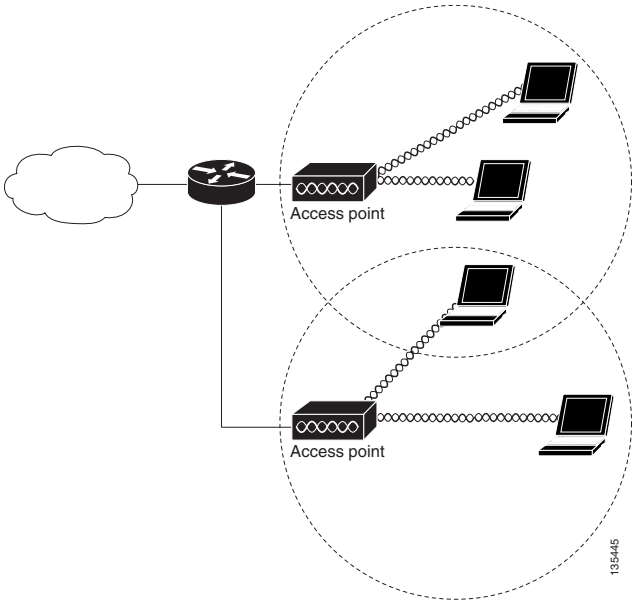
Setup the access point role in any of these common wireless network configurations. The access point default configuration is a root unit connected to a wired LAN or the central unit in an all-wireless network.

- Root Access Point, page 240
- Central Unit in an All-Wireless Network, page 241

Root Access Point

An access point connected directly to a wired LAN provides a connection point for wireless users. If more than one access point is connected to the LAN, users can roam from one area of a facility to another without losing their connection to the network. As users move out of range of one access point, they automatically connect to the network (associate) through another access point. The roaming process is seamless and transparent to the user. Figure 1 shows access points acting as root units on a wired LAN.

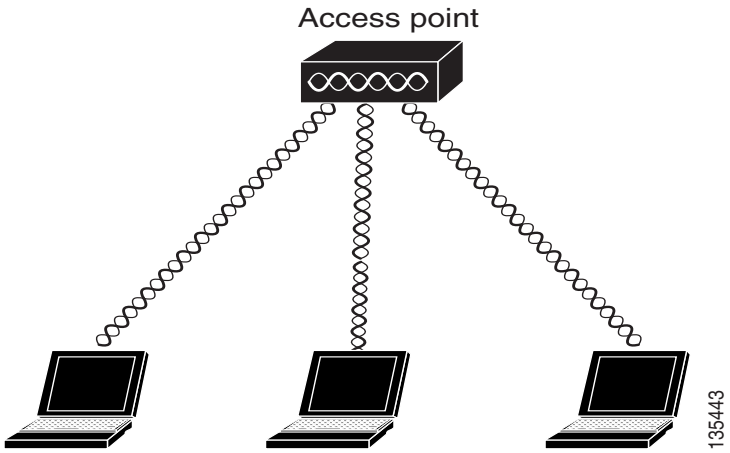
Figure 1 Access Points as Root Units on a Wired LAN



Central Unit in an All-Wireless Network

In an all-wireless network, an access point acts as a stand-alone root unit. The access point is not attached to a wired LAN; it functions as a hub linking all stations together. The access point serves as the focal point for communications, increasing the communication range of wireless users. Figure 2 shows an access point in an all-wireless network.

Figure 2 Access Point as Central Unit in All-Wireless Network



Configuring the Wireless Device

The following sections describe how to configure the wireless device on the Cisco 1941W integrated services router (ISR):

- Starting a Wireless Configuration Session, page 243
- Configuring Wireless Settings, page 245
- Upgrading to Cisco Unified Software, page 251
- Related Documentation, page 254

Note You can upgrade the software on the device to Cisco Unified software. See the "Upgrading to Cisco Unified Software" section on page 251.

Note The wireless device is embedded on the router and does not have an external console port for connections. To configure the wireless device, use a console cable to connect a personal computer to the host router's Console serial port, and follow the instruction to establish a configuration session.

Starting a Wireless Configuration Session

Enter the following commands in global configuration mode on the router's Cisco IOS command-line interface (CLI).

SUMMARY STEPS

1. **interface wlan-ap0**
2. **ip address** ***subnet mask***
3. **no shut**
4. **interface vlan1**
5. **ip address** ***subnet mask***
6. **exit**
7. **exit**
8. **service-module wlan-ap 0 session**

DETAILED STEPS

	Command	Purpose

Step 1	**interface wlan-ap0**
	
	Example:
	`router(config)# interface wlan-ap0`
	`router(config-if)#`
		Defines the router's console interface to the wireless device. It is used for communication between the router's Console and the wireless device.
		Always use port 0.
		The following message appears:
		`The wlan-ap 0 interface is used for managing the embedded AP. Please use the` **`service-module wlan-ap 0 session`** `command to console into the embedded AP.`

Step 2	**ip address** *subnet mask*
	
	Example:
	`router(config-if)# ip address 10.21.0.20 255.255.255.0`
	
	Example:
	`router(config-if)# ip unnumbered vlan1`
		Specifies the interface IP address and subnet mask.
		Note The IP address can be shared with the IP address assigned to the Cisco Integrated Services Router by using the **ip unnumbered vlan1** command.

Step 3	**no shut** **Example:** `router(config-if)# no shut`	Specifies the internal interface connection remains open.
Step 4	**interface vlan1** **Example:** `router(config-if)# interface vlan1`	Specifies the virtual LAN interface for data communication on the internal GE0[1] port to other interfaces.
Step 5	**ip address** *subnet mask* **Example:** `router(config-if)# ip address 10.10.0.30 255.255.255.0`	Specifies the interface IP address and subnet mask.

Step 6	**exit**
	
	Example:
	`router(config-if)# exit`
	`router(config)#`
		Exits the mode.

	Command	Purpose

Step 7	**exit**
	
	Example:
	`router(config)# exit`
	`router#`
		Exits the mode.

Step 8	**service-module wlan-ap 0 session**
	
	Example:
	`router# service-module wlan-ap0 session`
	`Trying 10.21.0.20, 2002 ... Open`
	
	`ap>`
		Opens the connection between the wireless device and the router's console.

1. GE0 = Gigabit Ethernet 0

Tip If you want to create an IOS software alias for the Console to session into the wireless device, enter the **alias exec dot11radio service-module wlan-ap 0 session** command at the EXEC prompt. After entering this command, you automatically skip to the **dot11 radio** level in the IOS.

Closing the Session

To close the session between the wireless device and the router's console, perform both of the following steps.

Wireless Device

1. **Control-Shift-6 x**

Router

2. **disconnect**
3. Press **Enter** twice.

Configuring Wireless Settings

Note If you are configuring the autonomous wireless device for the first time, start a configuration session between the router and the access point before attempting to configure basic wireless settings. See the "Starting a Wireless Configuration Session" section on page 243.

Configure the wireless device with the appropriate software tool.

- Unified software—Cisco Express Setup, page 246
- Autonomous software—Cisco IOS CLI, page 246

Cisco Express Setup

To configure the Cisco Unified wireless device use the web-browser Cisco Express Setup tool:

Step 1 Establish a Console connection to the wireless device and get the BVI IP address by entering the **show interface bvi1 IOS** command.

Step 2 Open a browser window and enter the BVI IP address in the browser-window address line. Press enter and an Enter Network Password window appears.

Step 3 Enter your username. *Cisco* is the default User Name.

Step 4 Enter the wireless device password. *Cisco* is the default password. The Summary Status page appears. See the following URL for details about using the web-browser configuration page: http://cisco.com/en/US/docs/wireless/access_point/12.4_10b_JA/configuration/guide/scg12410b-chap4-first.html#wp1103336

Cisco IOS CLI

To configure the Autonomous wireless device, establish a session between the router and the access point, then use the Cisco IOS CLI tool:

- Configuring the Radio, page 246
- Configuring Wireless Security Settings, page 247
- Configuring Wireless Quality of Service, page 250 (Optional)
- Configuring the Access Point in Hot Standby Mode, page 251 (Optional)

Configuring the Radio

Configure the radio parameters on the wireless device to transmit signals. See Chapter 9, "Configuring Radio Settings," for specific configuration procedures.

Configuring Wireless Security Settings

- Configuring Authentication, page 247
- Configuring WEP and Cipher Suites, page 248
- Configuring Wireless VLANs, page 248
- Configuring the Access Point in Hot Standby Mode, page 251

Configuring Authentication

Authentication types are tied to the Service Set Identifiers (SSIDs) that are configured for the access point. If you want to serve different types of client devices with the same access point, configure multiple SSIDs.

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

See *Authentication Types for Wireless Devices* at Cisco.com to select an authentication type: http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SecurityAuthenticationTypes.html

See *RADIUS and TACACS+ Servers in a Wireless Environment* at Cisco.com to set up a maximum security environment: http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SecurityRadiusTacacs_1.html.

Configuring Access Point as Local Authenticator

To provide local authentication service or backup authentication service for a WAN link failure or circumstance where a server fails, 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 Light Extensible Authentication Protocol (LEAP), Extensible Authentication Protocol-Flexible Authentication Secure Tunneling (EAP-FAST), or MAC-based authentication. The access point performs up to five authentications per second.

You configure the local authenticator access point manually with client user names and passwords because it does not synchronize its database with Remote Authentication Dial-In User Service (RADIUS) servers. You can specify a VLAN and a list of SSIDs that a client is allowed to use.

See *Using the Access Point as a Local Authenticator* at Cisco.com for details about setting up the wireless device in this role: http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SecurityLocalAuthent.html

Configuring WEP and Cipher Suites

Wired Equivalent Privacy (WEP) encryption scrambles the data transmitted between wireless devices to keep the communication private. Wireless devices and their wireless client devices use the same WEP key to encrypt and decrypt data. WEP keys encrypt both unicast and multicast messages. Unicast messages are addressed to one device on the network. Multicast messages are addressed to multiple devices on the network.

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) or Cisco Centralized Key Management (CCKM).

Cipher suites that contain TKIP provide the best security for your wireless LAN. Cipher suites that contain only WEP are the least secure.

See *Configuring WEP and Cipher Suites* for encryption procedures:
http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SecurityCipherSuitesWEP.html

Configuring Wireless VLANs

If you use VLANs on your wireless LAN and assign SSIDs to VLANs you can create multiple SSIDs by using any of the four security settings defined in the "Security Types" section on page 249. 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 of protocols for each VLAN.

See *Configuring Wireless VLANs* at Cisco.com for more about wireless VLAN architecture:
http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/wireless_vlans.html

Note If you do not use VLANs on your wireless LAN, the security options that you can assign to SSIDs are limited because the encryption settings and authentication types are linked on the Express Security page.

Assigning SSIDs

You can configure up to 16 SSIDs on a wireless device in the role of an access point and configure a unique set of parameters for each SSID. For example, you might use one SSID to allow guests to have limited access to the network and another SSID to allow authorized users to have access to secure data.

See *Service Set Identifiers* at Cisco.com for more about creating multiple SSIDs,
http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/ServiceSetID.html.

Note Without VLANs, encryption settings (WEP and ciphers) apply to an interface, such as the 2.4-GHz radio, and you cannot use more than one encryption setting on an interface. For example, when you create an SSID with static WEP with VLANs disabled, you cannot create additional SSIDs with Wi-Fi Protected Access (WPA) authentication because the SSIDs use different encryption settings. If you find that the security setting for an SSID conflicts with the settings for another SSID, you can delete one or more SSIDs to eliminate the conflict.

Security Types

Table 1 describes the four security types that you can assign to an SSID.

Table 1 Types of SSID Security

Security Type	Description	Security Features Enabled
No Security	This is the least secure option. You should use this option only for SSIDs used in a public space and assign it to a VLAN that restricts access to your network.	None.
Static WEP Key	This option is more secure than no security. However, static WEP keys are vulnerable to attack. If you configure this setting, you should consider limiting association to the wireless device based on MAC address. See *Cipher Suites and WEP* at Cisco.com for configuration procedures, http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SecurityCipherSuitesWEP.html . Or If your network does not have a RADIUS server, consider using an access point as a local authentication server. See *Using the Access Point as a Local Authenticator* at Cisco.com for instructions, http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SecurityLocalAuthent.html.	Mandatory WEP. Client devices cannot associate using this SSID without a WEP key that matches the wireless device key.

Table 1 Types of SSID Security (continued)

Security Type	Description	Security Features Enabled
EAP[1] Authentication	This option enables 802.1X authentication (such as LEAP[2], PEAP[3], EAP-TLS[4], EAP-FAST[5], EAP-TTLS[6], EAP-GTC[7] EAP-SIM[8], and other 802.1X/EAP based products) This setting uses mandatory encryption, WEP, open authentication + EAP, network EAP authentication, no key management, RADIUS server authentication port 1645. You are required to enter the IP address and shared secret for an authentication server on your network (server authentication port 1645). Because 802.1X authentication provides dynamic encryption keys, you do not need to enter a WEP key.	Mandatory 802.1X authentication. Client devices that associate using this SSID must perform 802.1X authentication. If radio clients are configured to authenticate using EAP-FAST, open authentication with EAP should also be configured. If you do not configure open authentication with EAP, the following warning message appears: `SSID CONFIG WARNING: [SSID]: If radio clients are using EAP-FAST, AUTH OPEN with EAP should also be configured.`
WPA[9]	This option permits wireless access to users authenticated against a database through the services of an authentication server, then encrypts their IP traffic with stronger algorithms than those used in WEP. This setting uses encryption ciphers, TKIP[10], open authentication + EAP, network EAP authentication, key management WPA mandatory, and RADIUS server authentication port 1645. As with EAP authentication, you must enter the IP address and shared secret for an authentication server on your network (server authentication port 1645).	Mandatory WPA authentication. Client devices that associate using this SSID must be WPA-capable. If radio clients are configured to authenticate using EAP-FAST, open authentication with EAP should also be configured. If you don't configure open authentication with EAP, the following message appears: `SSID CONFIG WARNING: [SSID]: If radio clients are using EAP-FAST, AUTH OPEN with EAP should also be configured.`

1. EAP = Extensible Authentication Protocol.
2. LEAP = Lightweight Extensible Authentication Protocol.
3. PEAP = Protected Extensible Authentication Protocol.
4. EAP-TLS = Extensible Authentication Protocol - Transport Layer Security.
5. EAP-FAST = Extensible Authentication Protocol-Flexible Authentication via Secure Tunneling.
6. EAP-TTLS = Extensible Authentication Protocol-Tunneled Transport Layer Security.
7. EAP-GTC = Extensible Authentication Protocol--Generic Token Card.
8. EAP-SIM = Extensible Authentication Protocol--Subscriber Identity Module.
9. WA = Wi-Fi Protected Access.
10. TKIP = Temporal Key Integrity Protocol.

Configuring Wireless Quality of Service

Configuring Quality of Service (QoS) can provide preferential treatment to certain traffic at the expense of other traffic. Without QoS, the device 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. To configure quality of service (QoS) for your wireless device, see *Quality of Service in a Wireless Environment* at:
http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/QualityOfService.html.

Configuring the Access Point in Hot Standby Mode

In hot standby mode, an access point is designated as a backup for another access point. The standby access point is placed near the access point that it monitors and is configured exactly like the monitored access point. The standby access point associates with the monitored access point as a client and sends Internet Access Point Protocol (IAPP) queries to the monitored access point through the Ethernet and radio ports. If the monitored access point fails to respond, the standby access point comes online and takes the monitored access point's place in the network.

Except for the IP address, the standby access point's settings should be identical to the settings on the monitored access point. If the monitored access point goes off line and the standby access point takes its place in the network, matching settings ensure that client devices can switch easily to the standby access point. See *Hot Standby Access Points* at Cisco.com for more information: http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/RolesHotStandby.html.

Upgrading to Cisco Unified Software

To run the access point in Cisco Unified mode, upgrade the software by following these major steps:

- Preparing for the Upgrade, page 251
- Performing the Upgrade, page 252
- Downgrading the Software on the Access Point, page 253
- Recovering Software on the Access Point, page 253

Software Prerequisites

- Cisco 1941W ISRs are eligible to upgrade to Cisco Unified software, if the router is running IP Base feature set and Cisco IOS Release 15.0(1)M.
- To use the embedded access point in a Cisco Unified Architecture, the Cisco wireless LAN controller (WLC) must be running version 5.1 or later.

Preparing for the Upgrade

Perform these tasks to prepare for the upgrade:

- Secure an IP Address on the Access Point, page 251
- Prior to the Upgrade, page 252

Secure an IP Address on the Access Point

Secure an IP address on the access point so it can communicate with the WLC and download the Unified image upon boot up. The host router provides the access point DHCP server functionality through the DHCP pool. Then the access point communicates with the WLC and setup option 43 for the controller IP address in the DHCP pool configuration. The following is a sample configuration:

```
ip dhcp pool embedded-ap-pool
network 60.0.0.0 255.255.255.0
dns-server 171.70.168.183
default-router 60.0.0.1
option 43 hex  f104.0a0a.0a0f   (single WLC IP address(10.10.10.15) in hex format)
int vlan1
ip address 60.0.0.1 255.255.255.0
```

For more information about the WLC discovery process, see *Cisco Wireless LAN Configuration Guide* at Cisco.com:
http://www.cisco.com/en/US/docs/wireless/controller/4.0/configuration/guide/ccfig40.html

Prior to the Upgrade

Perform the following steps.

1. Ping the WLC from the router to confirm IP connectivity.
2. Enter the **service-module wlan-ap 0 session** command to establish a session with the access point.
3. Confirm that the access point is running an autonomous boot image.
4. Enter the **show boot** command on the access point to confirm the mode setting is enabled. The following is sample output for the command:

```
Autonomous-AP# show boot
BOOT path-list:      flash:ap801-k9w7-mx.124-10b.JA3/ap801-k9w7-mx.124-10b.JA3
Config file:         flash:/config.txt
Private Config file: flash:/private-config
Enable Break:        yes
Manual Boot:         yes
HELPER path-list:
NVRAM/Config file
buffer size:   32768
Mode Button:    on
```

Performing the Upgrade

To upgrade to Unified software, follow these steps:

Step 1 Issue the **service-module wlan-ap 0 bootimage unified** command to change the access point boot image to the Unified upgrade image, which is also known as a *recovery image*.

```
Router# conf terminal
Router(config)# service-module wlan-ap 0 bootimage unified
Router(config)# end
```

Note If the **service-module wlan-ap 0 bootimage unified** command does not work successfully, check to see whether the software license is still eligible.

On the access point console, use the **show boot** command to identify the access point's boot image path:

```
autonomous-AP# show boot
BOOT path-list:      flash:/ap801-rcvk9w8-mx/ap801-rcvk9w8-mx
```

Step 2 Issue the **service-module wlan-ap 0 reload** command to perform a graceful shutdown and reboot the access point and complete the upgrade process. Session into the access point and monitor the upgrade process.

See the "Cisco Express Setup" section on page 246 for details about using the Web-based configuration page to configure the wireless device settings.

Troubleshooting an Upgrade or Reverting the AP to Autonomous Mode

Q. My access point failed to upgrade from autonomous software to Unified software and it appears to be stuck in the recovery mode. What is my next step?

A. Check the following items:

- Is the IP address on the BVI interface on the same subnet as the WLC?
- Can you ping the WLC from the router/access point to confirm connectivity?
- Is the access point set to the current date and time? Use the **show clock** command to confirm this information.

Q. My access point is attempting to boot, but it keeps failing. Why?
My access point is stuck in the recovery image and will not upgrade to the Unified software. Why?

A. The access point is stuck in recovery mode and you must use the **service-module wlan-ap0 reset bootloader** command to return the access point back to bootloader for manual image recovery.

Downgrading the Software on the Access Point

Use the **service-module wlan-ap0 bootimage autonomous** command to reset the access point BOOT back to the last autonomous image. Use the **service-module wlan-ap 0 reload** command to reload the access point with the autonomous software image.

Recovering Software on the Access Point

To recover the image on the access point, use the **service-module wlan-ap0 reset bootloader** command. This command returns the access point to the bootloader for manual image recovery.

Caution Use this command with caution. Use this command only to recover from a shutdown or failed state.

Related Documentation

See the following documentation for additional autonomous and unified configuration information:

- Autonomous Documentation—Table 2
- Unified Documentation—Table 3

Table 2 Autonomous Documentation

Network Design	Links	Description
Wireless Overview	"Wireless Device Overview"	Describes the roles of the wireless device on the network.
Configuration	**Links**	
Configuring the Radio	"Configuring Radio Settings"	Describes how to configure the wireless radio.
Security	**Links**	
Authentication Types for Wireless Devices	http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SecurityAuthenticationTypes.html	Describes the authentication types that are configured on the access point.
RADIUS and TACACS+ Servers in a Wireless Environment	http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SecurityRadiusTacacs_1.html	Describes how to enable and configure the RADIUS[1] and TACACS+[2] and provides detailed accounting information and flexible administrative control over authentication and authorization processes. RADIUS and TACACS+ are facilitated through AAA and can be enabled only through AAA commands.
Using the Access Point as a Local Authenticator	http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SecurityLocalAuthent.html	Describes how to use a wireless device in the role of an access point as a local authenticator, serving as a standalone authenticator for a small wireless LAN, or providing backup authentication service. As a local authenticator, the access point performs LEAP, EAP-FAST, and MAC-based authentication for up to 50 client devices.
Cipher Suites and WEP	http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SecurityCipherSuitesWEP.html	Describes how to configure the cipher suites required for using WPA[3] and CCKM[4]; WEP[5]; and WEP features including AES[6], MIC[7], TKIP[8], and broadcast key rotation.
Hot Standby Access Points	http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/RolesHotStandby.html	Describes how to configure your wireless device as a hot standby unit.
Configuring Wireless VLANs	http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/wireless_vlans.html	Describes how to configure an access point to operate with the VLANs set up on a wired LAN.
Service Set Identifiers	http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/ServiceSetID.html	In the role of an access point, a wireless device can support up to 16 SSIDs[9]. This document describes how to configure and manage SSIDs on the wireless device.
Administering	**Links**	**Description**
Administering the Access Point	"Administering the Wireless Device"	Describes how to administer the wireless device on the network.

Table 2 Autonomous Documentation (continued)

Quality of Service	http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/QualityOfService.html	Describes how to configure QoS[10] on your Cisco wireless interface. With this feature, you can provide preferential treatment to certain traffic at the expense of other traffic. Without QoS, the device 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.
Regulatory Domains and Channels	http://www.cisco.com/en/US/docs/routers/access/800/860-880-890/software/configuration/guide/scg_chanels.html	Lists the radio channels supported by Cisco access products in the regulatory domains of the world.
System Message Logging	http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SysMsgLogging.html	Describes how to configure system message logging on your wireless device.

1. RADIUS = Remote Authentication Dial-In User Service
2. TACACS+ = Terminal Access Controller Access Control System Plus
3. WPA = Wireless Protected Access
4. CCKM = Cisco Centralized Key Management
5. WEP = Wired Equivalent Privacy
6. AES = Advanced Encryption Standard
7. MIC = Message Integrity Check
8. TKIP = Temporal Key Integrity Protocol
9. SSID = service set identifiers
10. QoS = quality of service

Table 3 Unified Documentation

Network Design	Links
Why Migrate to the Cisco Unified Wireless Network?	http://www.cisco.com/en/US/solutions/ns175/networking_solutions_products_genericcontent0900aecd805299ff.html
Wireless LAN Controller (WLC) FAQ	http://www.cisco.com/en/US/products/ps6366/products_qanda_item09186a008064a991.shtml
Cisco IOS Command Reference for Cisco Aironet Access Points and Bridges, versions 12.4(10b) JA and 12.3(8) JEC	http://www.cisco.com/en/US/docs/wireless/access_point/12.4_10b_JA/command/reference/cr2410b.html
Cisco Aironet 1240AG Access Point Support Documentation	http://www.cisco.com/en/US/docs/wireless/access_point/1240/quick/guide/ap1240qs.html
Cisco 4400 Series Wireless LAN Controllers Support Documentation	http://www.cisco.com/en/US/products/ps6366/tsd_products_support_series_home.html

Configuring Radio Settings

The following sections describe how to configure radio settings for the wireless device:

- Enabling the Radio Interface, page 257
- Configuring the Role in the Radio Network, page 259
- Configuring Dual-Radio Fallback, page 261
- Configuring Radio Data Rates, page 262
- Configuring MCS Rates, page 265
- Configuring Radio Transmit Power, page 267
- Configuring Radio Channel Settings, page 269
- Enabling and Disabling World Mode, page 275
- Disabling and Enabling Short Radio Preambles, page 277
- Configuring Transmit and Receive Antennas, page 278
- Enabling and Disabling Gratuitous Probe Response, page 279
- Configuring the Ethernet Encapsulation Transformation Method, page 281
- Enabling and Disabling Public Secure Packet Forwarding, page 282
- Configuring the Beacon Period and the DTIM, page 284
- Configure RTS Threshold and Retries, page 285
- Configuring the Maximum Data Retries, page 286
- Configuring the Fragmentation Threshold, page 286
- Enabling Short Slot Time for 802.11g Radios, page 287
- Performing a Carrier Busy Test, page 287
- Configuring VoIP Packet Handling, page 288

Enabling the Radio Interface

The wireless device radios are disabled by default.

Note You must create a service set identifier (SSID) before you can enable the radio interface.

To enable the access point radio, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **dot11 ssid** *ssid*
3. **interface dot11radio {0| 1}**
4. **ssid** *ssid*
5. **no shutdown**
6. **end**
7. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**dot11 ssid** *ssid*	Enters the SSID. The SSID consists of up to 32 alphanumeric characters. SSIDs are case sensitive.
Step 3	**interface dot11radio {0| 1}**	Enters interface configuration mode for the radio interface.The 2.4-GHz and 802.11g/n 2.4-GHz radios are radio 0. The 5-GHz and the 802.11n 5-GHz radio is radio 1.
Step 4	**ssid** *ssid*	Assigns the SSID that you created in Step 2 to the appropriate radio interface.
Step 5	**no shutdown**	Enables the radio port.
Step 6	**end**	Returns to privileged EXEC mode.
Step 7	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

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

Configuring the Role in the Radio Network

The radio performs the following roles in the wireless network:

- Access point
- Access point (fallback to radio shutdown)
- Root bridge
- Non-root bridge
- Root bridge with wireless clients
- Non-root bridge without wireless clients

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 default fallback role for Cisco ISR wireless devices is as follows:

Shutdown—the wireless device shuts down its radio and disassociates all client devices.

To set the wireless device's radio network role and fallback role, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio {0| 1}**
3. **station-role**
4. **non-root** {**bridge** | **wireless-clients**}
   root {**access-point** | **ap-only** | **[bridge** | **wireless-clients**] | **[fallback** | **repeater** | **shutdown**]}
5. **workgroup-bridge** {**multicast** | **mode** <*client* | *infrastructure*>| universal <*Ethernet client MAC address*>}
6. **end**
7. **copy running-config startup-config**

DETAILED STEPS

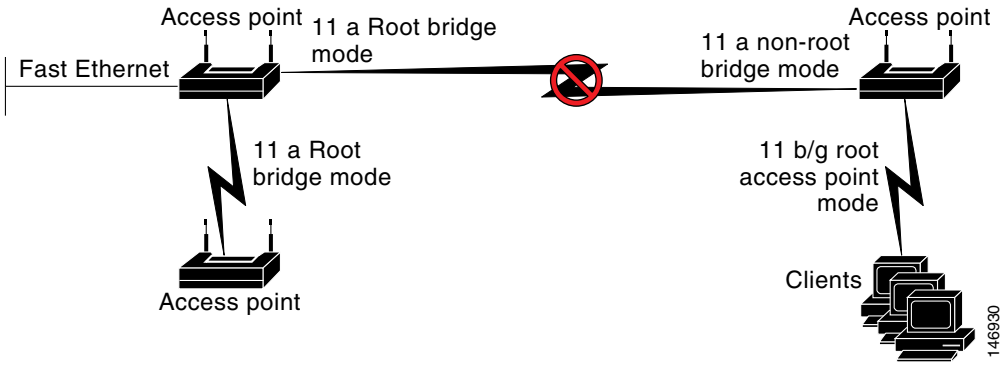
	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio {0| 1}**	Enters interface configuration mode for the radio interface. The 2.4-GHz and 802.11g/n 2.4-GHz radios are radio 0. The 5-GHz and the 802.11n 5-GHz radio is radio 1.
Step 3	**station-role** **non-root** {**bridge** | **wireless-clients**} **root** {**access-point** | **ap-only** | **[bridge** | **wireless-clients**] | **[fallback** | **repeater** | **shutdown**]} **workgroup-bridge** {**multicast** | **mode** <*client* | *infrastructure*>| universal <*Ethernet client MAC address*>}	Sets the wireless device role. • Set the role to non-root bridge with or without wireless clients, to root access point or bridge, or to workgroup bridge. **Note** The **bridge** mode radio supports point-to-point configuration only. **Note** The **repeater** and **wireless-clients** commands are not supported on Cisco 1941-W Integrated Services Routers. **Note** The **scanner** command is not supported on 1941-W Integrated Services Routers. • 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. A workgroup bridge can have a maximum of 25 clients, presuming that no other wireless clients are associated to the root bridge or access point.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Note When you enable the role of a device in the radio network as a bridge/workgroup bridge and enable the interface using the **no shut** command, the physical status and the software status of the interface will be up (ready) only if the device on the other end (access point or bridge) is up. Otherwise, only the physical status of the device will be up. The software status will be up when the device on the other end is configured and ready.

Configuring Dual-Radio Fallback

The dual-radio fallback feature, see Figure 1, allows you to configure access points so that if the non-root bridge link connecting the access point to the network infrastructure goes down, the root access point link through which a client connects to the access point shut down. Shutting down the root access point link causes the client to roam to another access point. Without this feature, the client remains connected to the access point, but won't be able to send or receive data from the network.

Figure 1 Dual-Radio Fallback



Note This feature does not affect the fallback feature for single-radio access points.

You can configure dual-radio fallback in three ways:

- Radio tracking
- Fast Ethernet tracking
- MAC-address tracking

Radio Tracking

You can configure the access point to track or monitor the status of one of its radios. If the tracked radio goes down or is disabled, the access point shuts down the other radio. If the tracked radio comes up, the access point enables the other radio.

- To track radio 0, enter the following command:

  ```
  # station-role root access-point fallback track d0 shutdown
  ```

- To track radio 1, enter the following command:

  ```
  # station-role root access-point fallback track d1 shutdown
  ```

Fast Ethernet Tracking

You can configure the access point for fallback when its Ethernet port is disabled or disconnected from the wired LAN. You configure the access point for Fast Ethernet tracking as described in the "Configuring the Role in the Radio Network" section on page 259.

Note Fast Ethernet tracking does not support the repeater mode.

- To configure the access point for Fast Ethernet tracking, enter the following command:

```
# station-role root access-point fallback track fa 0
```

MAC-Address Tracking

You can configure the radio, whose role is root access point, to come up or go down by tracking a client access point, and using its MAC address on another radio. If the client disassociates from the access point, the root access point radio goes down. If the client reassociates with the access point, the root access point radio comes back up.

MAC-address tracking is most useful when the client is a non-root bridge access point connected to an upstream wired network.

For example, to track a client whose MAC address is 12:12:12:12:12:12, enter the following command:

```
# station-role root access-point fallback track mac-address 12:12:12:12:12:12 shutdown
```

Configuring Radio Data Rates

You use the data rate settings to choose the data rates that the wireless device uses for data transmission. The rates are expressed in megabits per second (Mb/s). The wireless device always attempts to transmit at the highest data rate set to **basic**, also known as **required** 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 Mb/s service only, set the 11-Mb/s 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 Mb/s, 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-Mb/s service only, set the 54-Mb/s 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-Mb/s rate to **basic** and sets the other rates to **enabled**.

The range setting allows the access point to extend the coverage area by compromising on the data rate. Therefore, if you have a client that cannot connect to the access point while other clients can, the client might not be within the coverage area of the access point. In such a case, using the range option will help extend the coverage area, and the client may be able to connect to the access point. Typically the trade-off is between throughput and range.

When the signal degrades (possibly due to distance from the access point), the rates renegotiate in order to maintain the link (but at a lower data rate). A link that is configured for a higher throughput simply drops when the signal degrades enough that it no longer sustains a configured high data rate, or the link roams to another access point with sufficient coverage, if one is available.

The balance between the two (throughput vs. range) is a design decision that must be made based on resources available to the wireless project, the type of traffic the users will be passing, the service level desired, and as always, the quality of the RF environment.When you enter **throughput** for the data rate setting, the wireless device sets all four data rates to **basic**.

Note When a wireless network has a mixed environment of 802.11b clients and 802.11g clients, make sure that data rates 1, 2, 5.5, and 11 Mb/s are set to **required** (**basic**) and that all other data rates are set to **enable**. The 802.11b adapters do not recognize the 54 Mb/s data rate and do not operate if data rates higher than 11 Mb/s are set to **required** on the connecting access point.

To configure the radio data rates, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0** | **1**}
3. **speed** *parameters*
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**	**1**}	Enters interface configuration mode for the radio interface. The 2.4-GHz and the 802.11g/n 2.4-GHz radios are radio 0. The 5-GHz and the 802.11n 5-GHz radio is radio 1.

	Command	Purpose
Step 3	**speed** 802.11b, 2.4-GHz radio: {[**1.0**] [**11.0**] [**2.0**] [**5.5**] [**basic-1.0**] [**basic-11.0**] [**basic-2.0**] [**basic-5.5**] | **range** | **throughput**} 802.11g, 2.4-GHz radio: {[**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**} 802.11a 5-GHz radio: {[**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** | **ofdm-throughput** | **default**} 802.11n 2.4-GHz radio: {[**1.0**] [**11.0**] [**12.0**] [**18.0**] [**2.0**] [**24.0**] [**36.0**] [**48.0**] [**5.5**] [**54.0**] [**6.0**] [**9.0**] [**basic-1.0**] [**basic-11.0**] [**basic-12.0**] [**basic-18.0**] [**basic-24.0**] [**basic-36.0**] [**basic-48.0**] [**basic-5.5**] [**basic-54.0**] [**basic-6.0**] [**basic-9.0**] [**default**] [**m0-7**] [**m0.**] [**m1.**] [**m10.**] [**m11.**] [**m12.**] [**m13.**] [**m14.**] [**m15.**] [**m2.**] [**m3.**] [**m4.**] [**m5.**] [**m6.**] [**m7.**] [**m8-15**] [**m8.**] [**m9.**] [**ofdm**] [**only-ofdm**] | **range** | **throughput**} 802.11n 5-GHz radio: {[**12.0**] [**18.0**] [**24.0**] [**36.0**] [**48.0**] [**54.0**] [**6.0**] [**9.0**] [**basic-12.0**] [**basic-18.0**] [**basic-24.0**] [**basic-36.0**] [**basic-48.0**] [**basic-54.0**] [**basic-6.0**] [**basic-9.0**] [**default**] [**m0-7**] [**m0.**] [**m1.**] [**m10.**] [**m11.**] [**m12.**] [**m13.**] [**m14.**] [**m15.**] [**m2.**] [**m3.**] [**m4.**] [**m5.**] [**m6.**] [**m7.**] [**m8-15**] [**m8.**] [**m9.**] | **range** | **throughput**}	Sets each data rate to **basic** or **enabled**, or enters **range** to optimize range or enters **throughput** to optimize throughput. • (Optional) Enter **1.0**, **2.0**, **5.5**, and **11.0** to set these data rates to **enabled** on the 802.11b, 2.4-GHz radio. Enter **1.0**, **2.0**, **5.5**, **6.0**, **9.0**, **11.0**, **12.0**, **18.0**, **24.0**, **36.0**, **48.0**, and **54.0** to set these data rates to **enabled** on the 802.11g, 2.4-GHz radio. Enter **6.0**, **9.0**, **12.0**, **18.0**, **24.0**, **36.0**, **48.0**, and **54.0** to set these data rates to **enabled** on the 5-GHz radio. • (Optional) Enter **basic-1.0**, **basic-2.0**, **basic-5.5**, and **basic-11.0** to set these data rates to **basic** on the 802.11b, 2.4-GHz radio. Enter **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**, and **basic-54.0** to set these data rates to **basic** on the 802.11g, 2.4-GHz radio. **Note** If the client must support the basic rate that you select, it cannot associate to the wireless device. If you select 12-Mb/s or higher for the basic data rate on the 802.11g radio, 802.11b client devices cannot associate to the wireless device 802.11g radio. Enter **basic-6.0**, **basic-9.0**, **basic-12.0**, **basic-18.0**, **basic-24.0**, **basic-36.0**, **basic-48.0**, and **basic-54.0** to set these data rates to **basic** on the 5-GHz radio. • (Optional) Enter **range** or **throughput** or **ofdm-throughput** (no ERP protection) to automatically optimize radio range or throughput. When you enter **range**, the wireless device sets the lowest data rate to **basic** and sets the other rates to **enabled**. When you enter **throughput**, the wireless device sets all data rates to **basic**. (Optional) On the 802.11g radio, enter **speed throughput ofdm** to set all OFDM rates (6, 9, 12, 18, 24, 36, and 48) to **basic** (**required**) and to 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. • (Optional) Enter **default** to set the data rates to factory default settings (not supported on 802.11b radios). On the 802.11g radio, the **default** option sets rates 1, 2, 5.5, and 11 to **basic**, and sets 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 802.11g radio. On the 5-GHz radio, the **default** option sets rates 6.0, 12.0, and 24.0 to **basic**, and sets rates 9.0, 18.0, 36.0, 48.0, and 54.0 to **enabled**. On the 802.11g/n 2.4-GHz radio, the **default** option sets rates 1.0, 2.0, 5.5, and 11.0 to **enabled**. On the 802.11g/n 5-GHz radio, the **default** option sets rates to 6.0, 12.0, and 24.0 to **enabled**. The modulation coding scheme (MCS) index range for both 802.11g/n radios is 0 to 15.

	Command	Purpose
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves 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:

```
ap1200# configure terminal
ap1200(config)# interface dot11radio 0
ap1200(config-if)# no speed basic-2.0 basic-5.5
ap1200(config-if)# end
```

Configuring MCS Rates

Modulation coding scheme (MCS) is a specification of PHY parameters consisting of modulation order (binary phase shift keying [BPSK], quaternary phase shift keying [QPSK], 16-quadrature amplitude modulation [16-QAM], 64-QAM) and forward error correction (FEC) code rate (1/2, 2/3, 3/4, 5/6). MCS is used in the wireless device 802.11n radios, which define 32 symmetrical settings (8 per spatial stream):

- MCS 0–7
- MCS 8–15
- MCS 16–23
- MCS 24–31

The wireless device supports MCS 0–15. High-throughput clients support at least MCS 0–7.

MCS is an important setting because it provides for potentially greater throughput. High-throughput data rates are a function of *MCS*, *bandwidth*, and *guard interval*. The 802.11a, b, and g radios use 20-MHz channel widths. Table 1 shows potential data rated based on MCS, guard interval, and channel width.

Table 1 Data Rates Based on MCS Settings, Guard Interval, and Channel Width

MCS Index	Guard Interval = 800 ns		Guard Interval = 400 ns	
	20-MHz Channel Width Data Rate (Mb/s)	40-MHz Channel Width Data Rate (Mb/s)	20-MHz Channel Width Data Rate (Mb/s)	40-MHz Channel Width Data Rate (Mb/s)
0	6.5	13.5	7 2/9	15
1	13	27	14 4/9	30
2	19.5	40.5	21 2/3	45
3	26	54	28 8/9	60
4	39	81	43 1/3	90
5	52	109	57 5/9	120
6	58.5	121.5	65	135
7	65	135	72 2/9	152.5
8	13	27	14 4/9	30
9	26	54	28 8/9	60
10	39	81	43 1/3	90
11	52	108	57 7/9	120
12	78	162	86 2/3	180
13	104	216	115 5/9	240
14	117	243	130	270
15	130	270	144 4/9	300

The legacy rates are as follows:

5 GHz: 6, 9, 12, 18, 24, 36, 48, and 54 Mb/s

2.4 GHz: 1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, and 54 Mb/s

MCS rates are configured using the **speed** command. The following example shows a **speed** setting for an 802.11g/n 2.4-GHz radio:

```
interface Dot11Radio0
no ip address
no ip route-cache
!
ssid 800test
!
speed basic-1.0 2.0 5.5 11.0 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0 m0. m1. m2. m3. m4. m8.
m9. m10. m11. m12. m13. m14. m15.
```

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 set the transmit power on access point radios, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio {0| 1}**
3. **power local** *level*
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the radio interface. The 2.4-GHz and the 802.11g/n 2.4-GHz radios are radio 0. The 5-GHz and the 802.11n 5-GHz radio is radio 1.
Step 3	**power local** These options are available for the 2.4-GHz 802.11n radio (in dBm): {**8**	**9**| **11**	**14**	**15**	**17**	**maximum**}	Sets the transmit power for the radio, or the 5-GHz radio so that the power level is allowed in your regulatory domain.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Use the **no** form of the **power local** 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 (DPC) to refer to limiting the power level on associated client devices.

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

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0**| **1**}
3. **power client** *level*
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the radio interface. The 2.4-GHz and 802.11g/n 2.4-GHz radios are radio 0. The 5-GHz and the 802.11n 5-GHz radio is radio 1.
Step 3	**power client** These options are available for 802.11n 2.4-GHz clients (in dBm): {**local** | **8** | **9** | **11** | **14** | **15** | **17** | **maximum**} These options are available for 802.11n 5-GHz clients (in dBm): {**local** | **8** | **11** | **13** | **14** | **15** | **maximum**}	Sets the maximum power level allowed on client devices that associate to the wireless device. Setting the power level to **local** sets the client power level to that of the access point. Setting the power level to **maximum** sets the client power to the allowed maximum. **Note** The settings allowed in your regulatory domain might differ from the settings listed here.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

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

Note Aironet extensions must be enabled to limit the power level on associated client devices. Aironet 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 hardware installation guide for the access point for the frequencies allowed in your domain.

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

The 5-GHz radio operates on 8 channels from 5180 to 5320 MHz, up to 27 channels from 5170 to 5850 MHz depending on regulatory domain. Each channel covers 20 MHz, and the bands for the channels overlap slightly. For best performance, use channels that are not adjacent (use channels 44 and 46, for example) for radios that are close to each other.

Caution The presence of too many access points in the same vicinity can create radio congestion that can reduce throughput. A careful site survey can determine the best placement of access points for maximum radio coverage and throughput.

802.11n Channel Widths

The 802.11n standard allows both 20-MHz and 40-Mhz channel widths consisting of two contiguous non-overlapping channels (for example, 2.4-GHz channels 1 and 6).

One of the 20-MHz channels is called the *control channel*. Legacy clients and 20-MHz high-throughput clients use the control channel. Only beacons can be sent on this channel. The second 20-MHz channel is called the *extension channel.* The 40-MHz stations may use this channel and the control channel simultaneously.

A 40-MHz channel is specified as a channel and extension, such as 1,1. In this example, the control channel is channel 1 and the extension channel is above it.

To set the wireless device channel width, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0** | **1**}
3. **channel** {*frequency* | **least-congested** | **width** [**20** | **40-above** | **40-below**] | **dfs**}
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0** | **1**}	Enters interface configuration mode for the radio interface. The 802.11g/n 2.4-GHz radio is radio 0. The 802.11n 5-GHz radio is radio 1.
Step 3	**channel** {*frequency* | **least-congested** | **width** [**20** | **40-above** | **40-below**] | **dfs**}	Sets the default channel for the wireless device radio.To search for the least-congested channel on startup, enter **least-congested**. Use the **width** option to specify a bandwidth to use. This option is available for the Cisco 800 series ISR wireless devices and consists of three available settings: **20**, **40-above**, and **40-below:** • Choosing **20** sets the channel width to 20 MHz. • Choosing **40-above** sets the channel width to 40 MHz with the extension channel above the control channel. • Choosing **40-below** sets the channel width to 40 MHz with the extension channel below the control channel. **Note** The **channel** command is disabled for 5-GHz radios that comply with European Union regulations on dynamic frequency selection (DFS). See the "Enabling and Disabling World Mode" section on page 275 for more information.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Dynamic Frequency Selection

Access points with 5-GHz radios configured at the factory for use in the United States, Europe, Singapore, Korea, Japan, Israel, and Taiwan now comply with regulations that require radio devices to use Dynamic Frequency Selection (DFS) to detect radar signals and avoid interfering with them. When an access points detects a radar on a certain channel, it avoids using that channel for 30 minutes. 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, the access point automatically uses DFS to set the operating frequency. 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.
- If participating in WDS, sends a DFS notification to the active WDS device that it is leaving the frequency.

- Randomly selects a different 5-GHz channel.
- If the channel selected is one of the channels in Table 2, 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.
- If participating in WDS, sends a DFS notification of its new operating frequency to the active WDS device.

Note You cannot manually select a channel for DFS-enabled 5-GHz radios in Europe and Singapore. The access points randomly selects a channel. However, in Japan, you can manually select a channel if a radar has not been detected on it for the previous 30 minutes. If you attempt to select a channel that is unavailable due to radar detection, the CLI displays a message stating the channel is unavailable.

The full list of channels that require DFS is shown in Table 2.

Table 2 DFS Channel List

Channel	Frequency	Channel	Frequency	Channel	Frequency
56	5280 MHz	108	5520 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
104	5500 MHz	124	5620 MHz	—	—

For autonomous operation, DFS requires random channel selection among the channels listed in Table 2. The user interface prevents you from manually configuring these channels. The channels that are not listed in Table 2 do not require random selection and may be manually configured.

Prior to transmitting on any channels listed in Table 2, the access point radio performs a Channel Availability Check (CAC). The CAC is a 60 second scan for the presence of radar signals on the channel. The following sample messages are displayed on the access point console showing the beginning and end of the CAC scan:

```
*Mar 6 07:37:30.423: %DOT11-6-DFS_SCAN_START: DFS: Scanning frequency 5500 MHz for
60 seconds
```

```
*Mar 6 07:37:30.385: %DOT11-6-DFS_SCAN_COMPLETE: DFS scan complete on frequency
5500 MHz
```

When operating on any of the DFS channels listed in Table 2, in addition to performing the CAC, the access point constantly monitors the channel for radar. If radar is detected, the access point stops forwarding data packets within 200 ms and broadcasts five beacons that include an 802.11h channel switch announcement, indicating the channel number that the access point begins using. The following example message displays on the access point console when radar is detected:

```
*Mar 6 12:35:09.750: %DOT11-6-DFS_TRIGGERED: DFS: triggered on frequency 5500 MHz
```

When radar is detected on a channel, that channel may not be used for 30 minutes. The access point maintains a flag in non-volatile storage for each channel that it detects radar on in the last 30 minutes. After 30 minutes, the flag is cleared for the corresponding channel. If the access point is rebooted before a flag is cleared, the non-occupancy time is reset to 30 minutes when the channel initializes.

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 Cisco recommends 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.

CLI Commands

The following sections describe CLI commands that apply to DFS.

Confirming that DFS is Enabled

Use the **show controllers dot11radio1** command to confirm that DFS is enabled. The command also includes indications that uniform spreading is required and channels that are in the non-occupancy period due to radar detection.

This example shows a line from the output for the show controller command for a channel on which DFS is enabled. The indications listed in the previous paragraph are shown in **bold**:

```
ap# show controller dot11radio1
!
interface Dot11Radio1
Radio <model>, Base Address 011.9290ec0, BBlock version 0.00, Software version 6.00.0
Serial number FOCO83114WK
Number of supported simultaneous BSSID on Dot11Radio1: 8
Carrier Set: Americas (OFDM) (US )
Uniform Spreading Required: Yes
Current Frequency: 5300 MHz Channel 60 (DFS enabled)
Current Frequency: 5300 MHz  Channel 60 (DFS enabled)
Allowed Frequencies: 5180(36) 5200(40) 5220(44) 5240(48) *5260(52) *5280(56) *53
00(60) *5320(64) *5500(100) *5520(104) *5540(108) *5560(112) *5580(116) *5660(13
2) *5680(136) *5700(140) 5745(149) 5765(153) 5785(157) 5805(161)
* = May only be selected by Dynamic Frequency Selection (DFS)

Listen Frequencies: 5170(34) 5190(38) 5210(42) 5230(46) 5180(36) 5200(40) 5220(4
4) 5240(48) 5260(52) 5280(56) 5300(60) 5320(64) 5500(100) 5520(104) 5540(108) 55
60(112) 5580(116) 5600(120) 5620(124) 5640(128) 5660(132) 5680(136) 5700(140) 57
45(149) 5765(153) 5785(157) 5805(161) 5825(165)

DFS Blocked Frequencies: none
Beacon Flags: 0; Beacons are enabled; Probes are enabled
Current Power: 17 dBm
Allowed Power Levels: -1 2 5 8 11 14 15 17
Allowed Client Power Levels: 2 5 8 11 14 15 17
...
```

Configuring a Channel

Use the **channel** command to configure a channel. The command for the interface is modified to only allow you to select a specific channel number and to enable DFS.

To configure a channel, follow these steps.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio1 dfs simulate**
3. **channel** {*number* | **dfs band** *<1–4>*}
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio1 dfs simulate**	Enters the configuration interface for the 802.11a radio
Step 3	**channel** {*number* | **dfs band** *<1–4>*}	Specifies the channel to use. For *number*, enter one of the following channels: 36, 40, 44, 48, 149, 153, 157, 161, 5180, 5200, 5220, 5240, 5745, 5765, 5785, or 5805. Enter **dfs** and one of the following frequency bands to use dynamic frequency selection on the selected channel: 1—5.150 to 5.250 GHz 2—5.250 to 5.350 Ghz 3—5.470 to 5.725 GHz 4—5.725 to 5.825 GHz If you attempt to configure a channel that may only be selected by dfs, the following message appears: `This channel number/frequency can only be used by Dynamic Frequency Selection (DFS)`
Step 4	**end**	Returns to the privileged EXEC mode.
Step 5	**show running-config**	Verifies your entries
Step 6	**copy running-config startup-config**	(Optional) Saves your entries to the configuration file.

The following example selects channel 36 and configures it to use DFS on a frequency band 1:

```
ap# configure terminal
ap(config)interface dot11radio1
ap(config-if) channel 36
ap(config-if)
```

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:

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

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

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

This example shows how to unblock all frequencies for DFS:

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

Simulating Radar Detection

You can simulate radar detection on the current channel using the **debug dot11 dfs simulate** command. The following example simulates radar on dfs channel 36. Five beacons are sent.

```
ap>enable
Password:
ap#debug dot11 dot11radio1 dfs simulate 36 5
```

The following is an example message displayed on the console when radar is detected:

```
*Mar 6 12:35:09.750: %DOG11-6-DFS_TRIGGERED: DFS: triggered on frequency 5500 MHz
```

Setting the 802.11n Guard Interval

The 802.11n guard interval is the period in nanoseconds between packets. Two settings are available: short (400ns) and long (800ns).

To to set the 802.11n guard interval, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0** | **1**}
3. **guard-interval {any | long}**
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**	**1**}	Enters interface configuration mode for the radio interface.The 802.11n 2.4-GHz radio is radio 0. The 802.11n 5-GHz radio is radio 1.
Step 3	**guard-interval** {**any**	**long**}	Specifies a guard interval. • **any** allows either the short (400ns) or long (800ns) guard interval. • **long** allows only the long (800ns) guard interval.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Enabling and Disabling World Mode

You can configure the wireless device to support 802.11d world mode, Cisco legacy world mode, or world mode roaming. 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 detect whether the wireless device is using 802.11d or Cisco legacy world mode and automatically use the world mode that matches the mode used by the wireless device.

You can also configure world mode to be always on. In this configuration, the access point essentially roams between countries and changes its settings as required.

World mode is disabled by default.

To enable world mode, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0**| **1**}
3. **world-mode** {**dot11d country_code** *code* {**both** | **indoor** | **outdoor**} | **world-mode roaming** | **legacy**}
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the radio interface.
Step 3	**world-mode** {**dot11d country_code** *code* {**both**	**indoor**	**outdoor**}	**world-mode roaming**	**legacy**}	Enables world mode. • Enter the **dot11d** option to enable 802.11d world mode. – When you enter the **dot11d** option, you must enter a 2-character ISO country code (for example, the ISO country code for the United States is **US**). You can find a list of ISO country codes at the ISO website. – After the country code, you must enter **indoor**, **outdoor**, or **both** to indicate the placement of the wireless device. • Enter the **legacy** option to enable Cisco legacy world mode. • Enter the **world-mode roaming** option to place the access point in a continuous world mode configuration. **Note** Aironet extensions must be enabled for legacy world mode operation, but Aironet extensions are not required for 802.11d world mode. Aironet extensions are enabled by default.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

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

Disabling and Enabling 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.
- Long—A long preamble ensures compatibility between the wireless device and all early models of Cisco Aironet Wireless LAN Adapters. 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.

To disable short radio preambles, follow these steps, beginning in privileged EXEC mode:

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0**| **1**}
3. **no preamble-short**
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the 2.4-GHz radio interface.
Step 3	**no preamble-short**	Disables short preambles and enable long preambles.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves 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 that the wireless device uses to receive and transmit data. There are three option settings for both the receive antenna (see step 4) and the transmit antenna (see step 5):

- Gain—Sets the resultant antenna gain in decibels (dB).
- 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.

To select the antennas that the wireless device uses to receive and transmit data, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0**| **1**}
3. **gain** *dB*
4. **antenna receive** {**diversity | left | right**}
5. **antenna transmit** {**diversity | left | right**}
6. **end**
7. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the radio interface. The 802.11g/n 2.4-GHz radio is radio 0. The 802.11n 5-GHz radio is radio 1.
Step 3	**gain** *dB*	Specifies the resultant gain of the antenna attached to the device. Enter a value from –128 to 128 dB. If necessary, you can use a decimal point in the value, such as "1.5".
Step 4	**antenna receive** {**diversity	left	right**}	Sets the receive antenna to diversity, left, or right. **Note** For best performance with two antennas, leave the receive antenna setting at the default setting, **diversity**. For one antenna, attach the antenna on the right and set the antenna for **right**.

	Command	Purpose
Step 5	**antenna transmit** {**diversity** | **left** | **right**}	Sets the transmit antenna to diversity, left, or right. **Note** For best performance with two antennas, leave the receive antenna setting at the default setting, **diversity**. For one antenna, attach the antenna on the right and set the antenna for **right**.
Step 6	**end**	Returns to privileged EXEC mode.
Step 7	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Enabling and Disabling Gratuitous Probe Response

Gratuitous Probe Response (GPR) aids in conserving battery power in dual mode phones that support cellular and WLAN modes of operation. GPR is available on 5-Ghz radios and is disabled by default. You can configure two GPR settings:

- Period—This setting determines the time between GPR transmissions in Kusec intervals from 10 to 255 (similar to the beacon period)
- Speed—The speed is the data rate used to transmit the GPR

Selecting a longer period reduces the amount of RF bandwidth consumed by the GPR with the possibility of shorter battery life. Selecting higher transmission speeds also reduces the amount of bandwidth consumed but at the expense of a smaller cell size.

To enable GPR and set its parameters, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio {**
3. **probe-response gratuitous** {**period** | **speed**}
4. **period** *Kusec*
5. **speed** {[**6.0**] [**9.0**] [**12.0**] [**18.0**] [**24.0**] [**36.0**] [**48.0**] [**54.0**]}
6. **end**
7. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio {**	Enters interface configuration mode for the 5-GHz radio interface.
Step 3	**probe-response gratuitous** {**period** | **speed**}	Enables the Gratuitous Probe Response feature using default period (10 Kusec) and speed (6.0 Mbps).
Step 4	**period** *Kusec*	(Optional) Accepts a value from 10 to 255. The default value is 10

	Command	Purpose
Step 5	**speed** {[**6.0**] [**9.0**] [**12.0**] [**18.0**] [**24.0**] [**36.0**] [**48.0**] [**54.0**]}	(Optional) Sets the response speed in Mbps. The default value is 6.0.
Step 6	**end**	Returns to privileged EXEC mode.
Step 7	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

The optional parameters can be configured independently or combined when you do not want to use the defaults, as shown in the following examples:

```
(config-if)# probe-response gratuitous period 30
(config-if)# probe-response gratuitous speed 12.0
(config-if)# probe-response gratuitous period 30 speed 12.0
```

Use the **no** form of the command to disable the GPR feature.

Disabling and Enabling Aironet Extensions

By default, the wireless device uses Cisco Aironet 802.11 extensions to detect the capabilities of Cisco Aironet client devices and to support features that require specific interaction between the wireless device and associated client devices. Aironet extensions must be enabled to support these features:

- Load balancing—Wireless device uses Aironet extensions to direct client devices to an access point that provides the best connection to the network on the basis of such factors 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 the wireless device and all associated client devices, adds a few bytes to each packet to make the packets tamper-proof.
- Cisco Key Integrity Protocol (CKIP)—Cisco's WEP key permutation technique is based on an early algorithm presented by the IEEE 802.11i security task group. The standards-based algorithm, Temporal Key Integrity Protocol (TKIP), does not require Aironet extensions to be enabled.
- World mode (legacy only)—Client devices with legacy world mode enabled receive carrier set information from the wireless device and adjust their settings automatically. Aironet 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 Aironet extensions disables the features listed above, but it sometimes improves the ability of non-Cisco client devices to associate to the wireless device. Aironet extensions are enabled by default. To disable Aironet extensions, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0**| **1**}
3. **no dot11 extension aironet**
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the radio interface. The 802.11g/n 2.4-GHz radio is radio 0. The 802.11n 5-GHz radio is radio 1.
Step 3	**no dot11 extension aironet**	Disables Aironet extensions.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Use the **dot11 extension aironet** command to enable Aironet 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 by using an encapsulation transformation method. These are the two transformation methods:

- 802.1H—This method provides optimum performance for Cisco wireless products.
- RFC 1042—Use this setting to ensure interoperability with non-Cisco wireless equipment. RFC1042 does not provide the interoperability advantages of 802.1H but is used by other manufacturers of wireless equipment.

To configure the encapsulation transformation method, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0**| **1**}
3. **payload-encapsulation {snap | dot1h}**
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the radio interface. The 802.11g/n 2.4-GHz radio is radio 0. The 802.11n 5-GHz radio is radio 1.
Step 3	**payload-encapsulation** {**snap**	**dot1h**}	Sets the encapsulation transformation method to RFC 1042 (**snap**) or 802.1h (**dot1h**, the default setting).
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Enabling and Disabling Public Secure Packet Forwarding

Public Secure Packet Forwarding (PSPF) prevents client devices that are associated to an access point from inadvertently sharing files or communicating with other client devices that are associated to the access point. PSPF 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 283 for instructions on setting up protected ports.

To enable and disable PSPF using command-line interface (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/en/US/docs/ios/12_2/ibm/configuration/guide/bcftb_ps1835_TSD_Products_Configuration_Guide_Chapter.html

PSPF is disabled by default. To enable PSPF, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0**| **1**}
3. **bridge-group** *group* **port-protected**
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the radio interface. The 802.11g/n 2.4-GHz radio is radio 0. The 802.11n 5-GHz radio is radio 1.
Step 3	**bridge-group** *group* **port-protected**	Enables PSPF.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

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

Configuring Protected Ports

To prevent communication between client devices that are 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.

To define a port on your switch as a protected port, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **switchport protected**
4. **end**
5. **show interfaces** *interface-id* **switchport**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface** *interface-id*	Enters interface configuration mode. Enter the type and number of the switch port interface to configure, such as **wlan-gigabitethernet0**.
Step 3	**switchport protected**	Configures the interface to be a protected port.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**show interfaces** *interface-id* **switchport**	Verifies your entries.
Step 6	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

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

For detailed information on protected ports and port blocking, see the "Configuring Port-Based Traffic Control" chapter in *Catalyst 3550 Multilayer Switch Software Configuration Guide, 12.1(12c)EA1*. Click this link to browse to that guide:

http://www.cisco.com/en/US/docs/switches/lan/catalyst3550/software/release/12.1_12c_ea1/configuration/guide/3550scg.html

Configuring the Beacon Period and the DTIM

The beacon period is the amount of time between access point beacons in kilomicroseconds (Kmicrosecs). One Kmicrosec 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 if the data beacon rate is set at 2, its default setting, then the wireless device sends a beacon containing a DTIM every 200 Kmicrosecs.

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

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0**| **1**}
3. **beacon period** ***value***
4. **beacon dtim-period** ***value***
5. **end**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the radio interface. The 802.11g/n 2.4-GHz radio is radio 0. The 802.11n 5-GHz radio is radio 1.
Step 3	**beacon period** *value*	Sets the beacon period. Enter a value in kilomicroseconds.
Step 4	**beacon dtim-period** *value*	Sets the DTIM. Enter a value in kilomicroseconds.
Step 5	**end**	Returns to privileged EXEC mode.
Step 6	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Configure RTS Threshold and Retries

The request to send (RTS) threshold determines the packet size at which the wireless device issues an 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 detect 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 2347 for all access points and bridges, and the default maximum RTS retries setting is 32.

To configure the RTS threshold and maximum RTS retries, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0**| **1**}
3. **rts threshold** *value*
4. **rts retries** *value*
5. **end**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the radio interface. The 2.4-GHz and the 802.11g/n 2.4-GHz radios are radio 0. The 5-GHz and the 802.11n 5-GHz radio is radio 1.
Step 3	**rts threshold** *value*	Sets the RTS threshold. Enter an RTS threshold from 0 to 2347.
Step 4	**rts retries** *value*	Sets the maximum RTS retries. Enter a setting from 1 to 128.
Step 5	**end**	Returns to privileged EXEC mode.
Step 6	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

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

Configuring the Maximum Data Retries

The maximum data retries setting determines the number of attempts that the wireless device makes to send a packet before it drops the packet. The default setting is 32.

To configure the maximum data retries, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0**| **1**}
3. **packet retries** ***value***
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the radio interface. The 802.11g/n 2.4-GHz radio is radio 0. The 802.11n 5-GHz radio is radio 1.
Step 3	**packet retries** *value*	Sets the maximum data retries. Enter a setting from 1 to 128.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Use the **no** form of the **packet retries** command to reset the setting to the default.

Configuring the 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 2346 bytes.

To configure the fragmentation threshold, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface dot11radio** {**0**| **1**}
3. **fragment-threshold** *value*
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface dot11radio** {**0**| **1**}	Enters interface configuration mode for the radio interface. The 802.11g/n 2.4-GHz and 5-GHz radios are radio 0. The 802.11n 5-GHz radio is radio 1.
Step 3	**fragment-threshold** *value*	Sets 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	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Use the **no** form of the **fragment-threshold** command to reset the setting to the default.

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.

In radio interface mode, enter the **short-slot-time** command to enable short slot time:

```
ap(config-if)# short-slot-time
```

Enter **no short-slot-time** command 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 redisplay the carrier busy test results.

Configuring VoIP Packet Handling

You can improve the quality of VoIP packet handling per radio on access points by enhancing 802.11 MAC behavior for lower latency for the class of service (CoS) 5 (Video) and CoS 6 (Voice) user priorities.

To configure VoIP packet handling on an access point, follow these steps:

Step 1 Using a browser, log in to the access point.

Step 2 Click **Services** in the task menu on the left side of the web-browser interface.

Step 3 When the list of Services expands, click **Stream**.

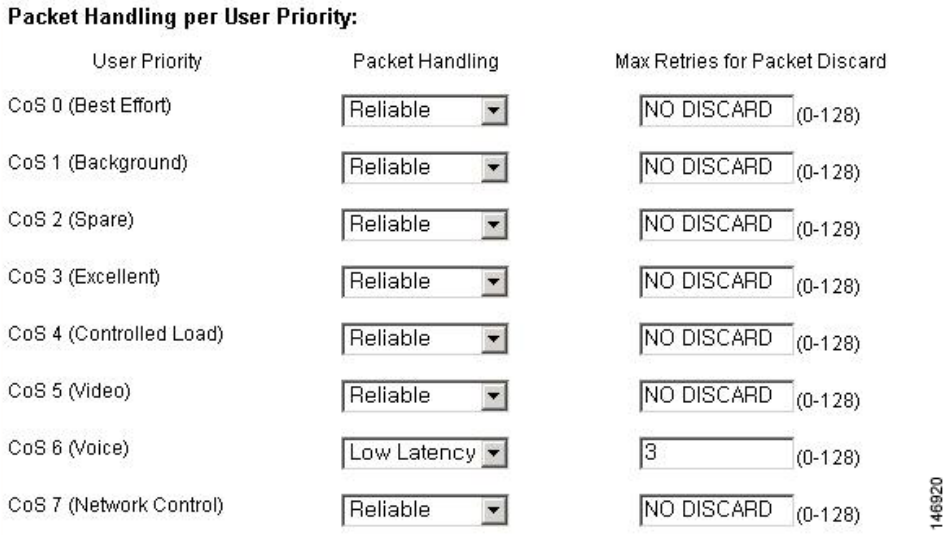
The Stream page appears.

Step 4 Click the tab for the radio to configure.

Step 5 For both CoS 5 (Video) and CoS 6 (Voice) user priorities, choose Low Latency from the Packet Handling drop-down menu, and enter a value for maximum retries for packet discard in the corresponding field.

The default value for maximum retries is 3 for the Low Latency setting (Figure 2). This value indicates how many times the access point will try to retrieve a lost packet before discarding it.

Figure 2 Packet Handling Configuration



Note You may also configure the CoS 4 (Controlled Load) user priority and its maximum retries value.

Step 6 Click **Apply**.

You can also configure VoIP packet handling using the CLI. For a list of Cisco IOS commands for configuring VoIP packet handling using the CLI, consult *Cisco IOS Command Reference for Cisco Aironet Access Points and Bridges*.

Administering the Wireless Device

The following sections describe administration tasks for the wireless device:

Security on the Wireless Device

- Disabling the Mode Button Function, page 291
- Preventing Unauthorized Access to Your Access Point, page 293
- Protecting Access to Privileged EXEC Commands, page 293
- Controlling Access Point Access with RADIUS, page 301
- Controlling Access Point Access with TACACS+, page 306

Administering the Wireless Device

- Administering the Wireless Hardware and Software, page 310
- Resetting the Wireless Device to the Factory Default Configuration, page 310
- Monitoring the Wireless Device, page 311
- Managing the System Time and Date, page 311
- Configuring a System Name and Prompt, page 317
- Creating a Banner, page 320

Configuring Wireless Device Communication

- Configuring Ethernet Speed and Duplex Settings, page 323
- Configuring the Access Point for Wireless Network Management, page 324
- Configuring the Access Point for Local Authentication and Authorization, page 324
- Configuring the Authentication Cache and Profile, page 326
- Configuring the Access Point to Provide DHCP Service, page 328
- Configuring the Access Point for Secure Shell, page 331
- Configuring Client ARP Caching, page 332
- Configuring Multiple VLAN and Rate Limiting for Point-to-Multipoint Bridging, page 333

Disabling the Mode Button Function

You can disable the mode button on the wireless device by using the **[no] boot mode-button** command.

Caution This command disables password recovery. If you lose the privileged EXEC mode password for the access point after entering this command, you will need to contact the Cisco Technical Assistance Center (TAC) to regain access to the access point command line interface (CLI).

Note To reboot the wireless device, use the **service-module wlan-ap reset** command from the Cisco IOS CLI. See the "Rebooting the Wireless Device" section on page 310 for information about this command.

The mode button is enabled by default. To disable the access point's mode button, Follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **no boot mode-button**
3. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**no boot mode-button**	Disables the access point's mode button.
Step 3	**end**	Returns to privileged EXEC mode. **Note** It is not necessary to save the configuration.

You can check the status of the mode button by executing the **show boot** or **show boot mode-button** command in privileged EXEC mode. The status does not appear in the running configuration. The following shows typical responses to the **show boot** and **show boot mode-button** commands:

```
ap# show boot
BOOT path-list: flash:/c1200-k9w7-mx-v123_7_ja.20050430/c1200-k9w7-mx.v123_7_ja.20050430
Config file: flash:/config.txt
Private Config file: flash:/private-config
Enable Break: no
Manual boot:no
Mode button:on
Enable IOS break: no
HELPER path-list:
NVRAM/Config file
    buffer size: 32768

ap#show boot mode-button
on
ap#
```

Note As long as the privileged EXEC password is known, you can use the **boot mode-button** command to restore the mode button to normal operation.

Preventing Unauthorized Access to Your Access Point

You can prevent unauthorized users from reconfiguring the wireless device and viewing configuration information. Typically, the network administrators must have access to the wireless device while restricting access to users who connect through a terminal or workstation from within the local network.

To prevent unauthorized access to the wireless device, configure one of these security features:

- Username and password pairs, which are locally stored on the wireless device. These pairs authenticate each user before the user can access the wireless device. You can also assign a specific privilege level (read only or read/write) to each username and password pair. For more information, see the "Configuring Username and Password Pairs" section on page 297. The default username is *Cisco*, and the default password is *Cisco*. Usernames and passwords are case sensitive.

  Note The characters TAB, ?, $, +, and [are invalid characters for passwords.

- Username and password pairs are stored centrally in a database on a security server. For more information, see the "Controlling Access Point Access with RADIUS" section on page 301.

Protecting Access to Privileged EXEC Commands

A simple way of providing terminal access control in your network is to use passwords and assign privilege levels. Password protection restricts access to a network or network device. Privilege levels define what commands users can issue after they have logged in to a network device.

Note For complete syntax and usage information for the commands used in this section, see *Cisco IOS Security Command Reference for Release 12.4*.

This section describes how to control access to the configuration file and privileged EXEC commands. It contains this configuration information:

- Configuring Default Password and Privilege Level, page 294
- Setting or Changing a Static Enable Password, page 294
- Protecting Enable and Enable Secret Passwords with Encryption, page 295
- Configuring Username and Password Pairs, page 297
- Configuring Multiple Privilege Levels, page 298

Configuring Default Password and Privilege Level

Table 1 shows the default password and privilege level configuration.

Table 1 Default Passwords and Privilege Levels

Privilege Level	Default Setting
Username and password	Default username is *Cisco,* and the default password is *Cisco.*
Enable password and privilege level	Default password is *Cisco*. The default is level 15 (privileged EXEC level). The password is encrypted in the configuration file.
Enable secret password and privilege level	Default enable password is *Cisco*. The default is level 15 (privileged EXEC level). The password is encrypted before it is written to the configuration file.
Line password	Default password is *Cisco*. The password is encrypted in the configuration file.

Setting or Changing a Static Enable Password

The enable password controls access to the privileged EXEC mode.

Caution The **no enable password** command in global configuration mode removes the enable password, but you should use extreme care when using this command. If you remove the enable password, you are locked out of the privileged EXEC mode.

To set or change a static enable password, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **enable password** ***password***
3. **end**
4. **show running-config**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**enable password** *password*	Defines a new password or changes an existing password for access to privileged EXEC mode. The default password is *Cisco*. For *password*, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. It can contain the question mark (?) character if you precede the question mark with the key combination Crtl-V when you create the password; for example, to create the password abc?123, do this: 1. Enter **abc**. 2. Enter **Crtl-V**. 3. Enter **?123**. When the system prompts you to enter the enable password, you need not precede the question mark with the Ctrl-V; you can simply enter **abc?123** at the password prompt. **Note** The characters TAB, ?, $, +, and [are invalid characters for passwords.
Step 3	**end**	Returns to privileged EXEC mode.
Step 4	**show running-config**	Verifies your entries.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

The enable password is not encrypted and can be read in the wireless device configuration file.

The following example shows how to change the enable password to *l1u2c3k4y5*. The password is not encrypted and provides access to level 15 (standard privileged EXEC mode access):

```
AP(config)# enable password l1u2c3k4y5
```

Protecting Enable and Enable Secret Passwords with Encryption

To provide an additional layer of security, particularly for passwords that cross the network or that are stored on a TFTP server, you can use either the **enable password** or **enable secret** command in global configuration mode. The commands accomplish the same thing; that is, you can establish an encrypted password that users must enter to access privileged EXEC mode (the default) or any privilege level that you specify.

We recommend that you use the **enable secret** command because it uses an improved encryption algorithm.

If you configure the **enable secret** command, it takes precedence over the **enable password** command; the two commands cannot be in effect simultaneously.

To configure encryption for enable and enable secret passwords, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **enable password** [**level** *level*] {*password* | *encryption-type encrypted-password*}

   or

   enable secret [**level** *level*] {*password* | *encryption-type encrypted-password*}
3. **service password-encryption**
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**enable password** [**level** *level*] {*password* | *encryption-type encrypted-password*}	Defines a new password or changes an existing password for access to privileged EXEC mode.
	or	or
	enable secret [**level** *level*] {*password* | *encryption-type encrypted-password*}	Defines a secret password, which is saved using a nonreversible encryption method. • (Optional) For *level*, the range is from 0 to 15. Level 1 is normal user EXEC mode privileges. The default level is 15 (privileged EXEC mode privileges). • For *password*, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. By default, no password is defined. • (Optional) For *encryption-type*, only type 5, a Cisco proprietary encryption algorithm, is available. If you specify an encryption type, you must provide an encrypted password—an encrypted password you copy from another access point wireless device configuration. **Note** If you specify an encryption type and then enter a clear text password, you cannot reenter privileged EXEC mode. You cannot recover a lost encrypted password by any method.
Step 3	**service password-encryption**	(Optional) Encrypts the password when the password is defined or when the configuration is written. Encryption prevents the password from being readable in the configuration file.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

If both the enable and enable secret passwords are defined, users must enter the enable secret password.

Use the **level** keyword to define a password for a specific privilege level. After you specify the level and set a password, give the password only to users who need to have access at this level. Use the **privilege level** command in global configuration mode to specify commands accessible at various levels. For more information, see the "Configuring Multiple Privilege Levels" section on page 298.

If you enable password encryption, it applies to all passwords, including username passwords, authentication key passwords, the privileged command password, and console and virtual terminal line passwords.

To remove a password and level, use the **no enable password** [**level** *level*] command or the **no enable secret** [**level** *level*] command in global configuration mode. To disable password encryption, use the **no service password-encryption** command in global configuration mode.

This example shows how to configure the encrypted password *1FaD0$Xyti5Rkls3LoyxzS8* for privilege level 2:

```
AP(config)# enable secret level 2 5 $1$FaD0$Xyti5Rkls3LoyxzS8
```

Configuring Username and Password Pairs

You can configure username and password pairs, which are locally stored on the wireless device. These pairs are assigned to lines or interfaces, and they authenticate each user before the user can access the wireless device. If you have defined privilege levels, you can also assign a specific privilege level (with associated rights and privileges) to each username and password pair.

To establish a username-based authentication system that requests a login username and a password, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **username** *name* [**privilege** *level*] {**password** *encryption-type password*}
3. **login local**
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**username** *name* [**privilege** *level*] {**password** *encryption-type password*}	Enters the username, privilege level, and password for each user. • For *name*, specify the user ID as one word. Spaces and quotation marks are not allowed. • (Optional) For *level*, specify the privilege level the user has after gaining access. The range is 0 to 15. Level 15 gives privileged EXEC mode access. Level 1 gives user EXEC mode access. • For *encryption-type*, enter 0 to specify that an unencrypted password will follow. Enter 7 to specify that a hidden password will follow. • For *password*, specify the password the user must enter to gain access to the wireless device. The password must be from 1 to 25 characters, can contain embedded spaces, and must be the last option specified in the **username** command.
Step 3	**login local**	Enables local password checking at login time. Authentication is based on the username specified in Step 2.
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**show running-config**	Verifies your entries.
Step 6	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

To disable username authentication for a specific user, use the **no username** *name* command in global configuration mode.

To disable password checking and allow connections without a password, use the **no login** command in line configuration mode.

Note You must have at least one username configured, and you must have login local set to open a Telnet session to the wireless device. If you do not enter a username for the only username, you can be locked out of the wireless device.

Configuring Multiple Privilege Levels

By default, Cisco IOS software has two modes of password security: user EXEC and privileged EXEC. You can configure up to 16 hierarchical levels of commands for each mode. By configuring multiple passwords, you can allow different sets of users to have access to specified commands.

For example, if you want many users to have access to the **clear line** command, you can assign it level 2 security and distribute the Level 2 password fairly widely. But if you want more restricted access to the **configure** command, you can assign it Level 3 security and distribute that password to a more restricted group of users.

This section includes this configuration information:

- Setting the Privilege Level for a Command, page 299
- Logging Into and Exiting a Privilege Level, page 300

Setting the Privilege Level for a Command

To set the privilege level for a command mode, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **privilege** *mode* **level** *level command*
3. **enable password level** *level password*
4. **end**
5. **show running-config**

   or

   show privilege
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**privilege** *mode* **level** *level command*	Sets the privilege level for a command. • For *mode*, enter **configure** for global configuration mode, **exec** for EXEC mode, **interface** for interface configuration mode, or **line** for line configuration mode. • For *level*, the range is from 0 to 15. Level 1 is for normal user EXEC mode privileges. Level 15 is the level of access permitted by the **enable** password. • For *command*, specify the command to which you want to restrict access.
Step 3	**enable password level** *level password*	Specifies the enable password for the privilege level. • For *level*, the range is from 0 to 15. Level 1 is for normal user EXEC mode privileges. • For *password*, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. By default, no password is defined. **Note** The characters TAB, ?, $, +, and [are invalid characters for passwords.
Step 4	**end**	Returns to privileged EXEC mode.

	Command	Purpose
Step 5	**show running-config** or **show privilege**	Verifies your entries. The **show running-config** command displays the password and access level configuration. The **show privilege** command displays the privilege level configuration.
Step 6	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

When you set a command to a privilege level, all commands whose syntax is a subset of that command are also set to that level. For example, if you set the **show ip route** command to level 15, the **show** commands and **show ip** commands are automatically set to privilege level 15 unless you set them individually to different levels.

To return to the default privilege for a given command, use the **no privilege** *mode* **level** *level command* command in global configuration mode.

The following example shows how to set the **configure** command to privilege level 14 and how to define *SecretPswd14* as the password users must enter to use level 14 commands:

```
AP(config)# privilege exec level 14 configure
AP(config)# enable password level 14 SecretPswd14
```

Logging Into and Exiting a Privilege Level

To log in to a specified privilege level or to exit to a specified privilege level, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **enable** *level*
2. **disable** *level*

DETAILED STEPS

	Command	Purpose
Step 1	**enable** *level*	Logs in to a specified privilege level. For *level*, the range is 0 to 15.
Step 2	**disable** *level*	Exits to a specified privilege level. For *level*, the range is 0 to 15.

Controlling Access Point Access with RADIUS

This section describes how to control administrator access to the wireless device by using Remote Authentication Dial-In User Service (RADIUS). For complete instructions on configuring the wireless device to support RADIUS, see the "Configuring Radius and TACACS+ Servers" chapter in *Cisco IOS Software Configuration Guide for Cisco Aironet Access Points*.

RADIUS provides detailed accounting information and flexible administrative control over authentication and authorization processes. RADIUS is facilitated through authentication, authorization, and accounting (AAA) and can be enabled only through AAA commands.

Note For complete syntax and usage information for the commands used in this section, see *Cisco IOS Security Command Reference*.

These sections describe RADIUS configuration:

- Default RADIUS Configuration, page 301
- Configuring RADIUS Login Authentication, page 301 (required)
- Defining AAA Server Groups, page 303 (optional)
- Configuring RADIUS Authorization for User Privileged Access and Network Services, page 305 (optional)
- Displaying the RADIUS Configuration, page 306

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 who are accessing the wireless device through the command-line interface (CLI).

Configuring RADIUS Login Authentication

To configure AAA authentication, you define a named list of authentication methods and then apply the 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 defined authentication methods are performed. The only exception is the default method list (which 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 used to authenticate a user. You can designate one or more security protocols 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—that is, the security server or local username database responds by denying the user access—the authentication process stops, and no other authentication methods are attempted.

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

SUMMARY STEPS

1. **configure terminal**
2. **aaa new-model**
3. **aaa authentication login** {**default** | *list-name*} *method1* [*method2...*]
4. **line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*]
5. **login authentication** {**default** | *list-name*}
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**aaa new-model**	Enables AAA.
Step 3	**aaa authentication login** {**default** | *list-name*} *method1* [*method2...*]	Creates a login authentication method list. • To create a default list that is used when a named list is *not* specified in the **login authentication** command, use the **default** keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all interfaces. • For *list-name*, specify a character string to name the list you are creating. • For *method1...*, 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. Select one of these methods: • **local**—Use the local username database for authentication. You must enter username information in the database. Use the **username** *password* global configuration command. • **radius**—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 of the "Configuring Radius and TACACS+ Servers" chapter in *Cisco IOS Software Configuration Guide for Cisco Aironet Access Points*.
Step 4	**line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*]	Enters line configuration mode, and configures the lines for which to apply the authentication list.

	Command	Purpose
Step 5	**login authentication** {**default** | *list-name*}	Applies the authentication list to a line or set of lines. • If you specify **default**, use the default list that you created with the **aaa authentication login** command. • For *list-name*, specify the list that you created with the **aaa authentication login** command.
Step 6	**end**	Returns to privileged EXEC mode.
Step 7	**show running-config**	Verifies your entries.
Step 8	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

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

Defining AAA Server Groups

You can configure the wireless device 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 can also 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 failover 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.

To define the AAA server group and associate a particular RADIUS server with it, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **aaa new-model**
3. **radius-server host** {*hostname* | *ip-address*} [**auth-port** *port-number*] [**acct-port** *port-number*] [**timeout** *seconds*] [**retransmit** *retries*] [**key** *string*]
4. **aaa group server radius** *group-name*
5. **server** *ip-address*
6. **end**
7. **show running-config**

8. **copy running-config startup-config**
9. **aaa authorization exec radius**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**aaa new-model**	Enables AAA.
Step 3	**radius-server host** {*hostname* | *ip-address*} [**auth-port** *port-number*] [**acct-port** *port-number*] [**timeout** *seconds*] [**retransmit** *retries*] [**key** *string*]	Specifies the IP address or hostname of the remote RADIUS server host. • (Optional) For **auth-port** *port-number*, specify the user datagram protocol (UDP) destination port for authentication requests. • (Optional) For **acct-port** *port-number*, specify the UDP destination port for accounting requests. • (Optional) For **timeout** *seconds*, specify the time interval that the wireless device waits for the RADIUS server to reply before retransmitting. The range is 1 to 1000. This setting overrides the **radius-server timeout** global configuration command setting. If no timeout is set with the **radius-server host** command, the setting of the **radius-server timeout** command is used. • (Optional) For **retransmit** *retries*, specify the number of times that 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 **radius-server host** command, the setting of the **radius-server retransmit** global configuration command is used. • (Optional) For **key** *string*, specify the authentication and encryption key used between the wireless device and the RADIUS daemon running on the RADIUS server. **Note** The key is a text string that must match the encryption key that is used on the RADIUS server. Always configure the key as the last item in the **radius-server host** 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. To configure the wireless device to recognize more than one host entry that is associated with a single IP address, enter this command as many times as necessary, making sure that each UDP port number is different. The wireless device 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.
Step 4	**aaa group server radius** *group-name*	Defines the AAA server-group with a group name. This command puts the wireless device in a server group configuration mode.
Step 5	**server** *ip-address*	Associates a particular RADIUS server with the defined server group. Repeat this step for each RADIUS server in the AAA server group. Each server in the group must be previously defined in Step 2.

	Command	Purpose
Step 6	**end**	Returns to privileged EXEC mode.
Step 7	**show running-config**	Verifies your entries.
Step 8	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.
Step 9	**aaa authorization exec radius**	Enables RADIUS login authentication. See the "Configuring RADIUS Login Authentication" section of the "Configuring Radius and TACACS+ Servers" chapter in *Cisco IOS Software Configuration Guide for Cisco Aironet Access Points*.

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

In the following is example, the wireless device is configured to recognize two different RADIUS group servers (*group1* and *group2*). Group1 has two different host entries on the same RADIUS server which are configured for the same services. The second host entry acts as a failover backup to the first entry.

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

Configuring RADIUS Authorization for User Privileged Access and Network Services

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

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

The **aaa authorization exec radius** 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.

To specify RADIUS authorization for privileged EXEC access and network services, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **aaa authorization network radius**
3. **aaa authorization exec radius**
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**aaa authorization network radius**	Configures the wireless device for user RADIUS authorization for all network-related service requests.
Step 3	**aaa authorization exec radius**	Configures the wireless device for user RADIUS authorization to determine whether the user has privileged EXEC access. The **exec** keyword might return user profile information (such as **autocommand** information).
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**show running-config**	Verifies your entries.
Step 6	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

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

Displaying the RADIUS Configuration

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

Controlling Access Point Access with TACACS+

This section describes how to control administrator access to the wireless device using Terminal Access Controller Access Control System Plus (TACACS+). For complete instructions on configuring the wireless device to support TACACS+, see the "Configuring Radius and TACACS+ Servers" chapter in *Cisco IOS Software Configuration Guide for Cisco Aironet Access Points*.

TACACS+ provides detailed accounting information and flexible administrative control over authentication and authorization processes. TACACS+ is facilitated through AAA and can be enabled only through AAA commands.

Note For complete syntax and usage information for the commands used in this section, see *Cisco IOS Security Command Reference*.

These sections describe TACACS+ configuration:

- Default TACACS+ Configuration, page 307
- Configuring TACACS+ Login Authentication, page 307
- Configuring TACACS+ Authorization for Privileged EXEC Access and Network Services, page 309
- Displaying the TACACS+ Configuration, page 310

Default TACACS+ Configuration

TACACS+ and AAA are disabled by default.

To prevent a lapse in security, you cannot configure TACACS+ through a network management application.When enabled, TACACS+ can authenticate administrators who are accessing the wireless device through the CLI.

Configuring TACACS+ Login Authentication

To configure AAA authentication, you define a named list of authentication methods and then apply the 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 defined authentication methods are performed. The only exception is the default method list (which 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 used to authenticate a user. You can designate one or more security protocols 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—that is, the security server or local username database responds by denying the user access—the authentication process stops, and no other authentication methods are attempted.

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

SUMMARY STEPS

1. **configure terminal**
2. **aaa new-model**
3. **aaa authentication login** {**default** | *list-name*} *method1* [*method2...*]
4. **line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*]
5. **login authentication** {**default** | *list-name*}
6. **end**

7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**aaa new-model**	Enables AAA.
Step 3	**aaa authentication login** {**default** | *list-name*} *method1* [*method2...*]	Creates a login authentication method list. • To create a default list that is used when a named list is *not* specified in the **login authentication** command, use the **default** keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all interfaces. • For *list-name*, specify a character string to name the list you are creating. • For *method1...*, 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. Select one of these methods: • **local**—Use the local username database for authentication. You must enter username information into the database. Use the **username** *password* command in global configuration mode. • **tacacs+**—Use TACACS+ authentication. You must configure the TACACS+ server before you can use this authentication method.
Step 4	**line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*]	Enters line configuration mode, and configure the lines to which you want to apply the authentication list.
Step 5	**login authentication** {**default** | *list-name*}	Applies the authentication list to a line or set of lines. • If you specify **default**, use the default list created with the **aaa authentication login** command. • For *list-name*, specify the list created with the **aaa authentication login** command.
Step 6	**end**	Returns to privileged EXEC mode.
Step 7	**show running-config**	Verifies your entries.
Step 8	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

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

Configuring TACACS+ Authorization for Privileged EXEC Access and Network Services

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

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

The **aaa authorization exec tacacs+ local** command sets these authorization parameters:

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

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

To specify TACACS+ authorization for privileged EXEC access and network services, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **aaa authorization network tacacs+**
3. **aaa authorization exec tacacs+**
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**aaa authorization network tacacs+**	Configures the wireless device for user TACACS+ authorization for all network-related service requests.
Step 3	**aaa authorization exec tacacs+**	Configures the wireless device for user TACACS+ authorization to determine whether the user has privileged EXEC access. The **exec** keyword might return user profile information (such as **autocommand** information).
Step 4	**end**	Returns to privileged EXEC mode.
Step 5	**show running-config**	Verifies your entries.
Step 6	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

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

Displaying the TACACS+ Configuration

To display TACACS+ server statistics, use the **show tacacs** command in privileged EXEC mode.

Administering the Wireless Hardware and Software

This section provides instructions for performing the following tasks:

- Resetting the Wireless Device to the Factory Default Configuration, page 310
- Rebooting the Wireless Device, page 310
- Monitoring the Wireless Device, page 311

Resetting the Wireless Device to the Factory Default Configuration

To reset the wireless device hardware and software to its factory default configuration, use the **service-module wlan-ap0 reset default-config** command in the router's Cisco IOS privileged EXEC mode.

Caution Because you may lose data, use only the **service-module wlan-ap0 reset** command to recover from a shutdown or failed state.

Rebooting the Wireless Device

To perform a graceful shutdown and reboot the wireless device, use the **service-module wlan-ap0 reload** command in the router's Cisco IOS privileged EXEC mode. At the confirmation prompt, press **Enter** to confirm the action, or enter **n** to cancel.

When running in autonomous mode, the reload command saves the configuration before rebooting. If the attempt is unsuccessful, the following message displays:

```
Failed to save service module configuration.
```

When running in Lightweight Access Point Protocol (LWAPP) mode, the reload function is typically handled by the wireless LAN controller (WLC). If you enter the **service-module wlan-ap0 reload** command, you are prompted with the following message:

```
The AP is in LWAPP mode. Reload is normally handled by WLC controller.

Still want to proceed? [yes]
```

Monitoring the Wireless Device

This section provides commands for monitoring hardware on the router.

- Displaying Wireless Device Statistics, page 311
- Displaying Wireless Device Status, page 311

Displaying Wireless Device Statistics

Use the **service-module wlan-ap0 statistics** command in privileged EXEC mode to display wireless device statistics. The following is sample output for the command:

```
  CLI reset count = 0
  CLI reload count = 1
  Registration request timeout reset count = 0
  Error recovery timeout reset count = 0
  Module registration count = 10

The last IOS initiated event was a cli reload at *04:27:32.041 UTC Fri Mar 8 2007
```

Displaying Wireless Device Status

Use the **service-module wlan-ap0 status** command in privileged EXEC mode to display the status of the wireless device and its configuration information. The following is sample output for the command:

```
Service Module is Cisco wlan-ap0
Service Module supports session via TTY line 2
Service Module is in Steady state
Service Module reset on error is disabled
Getting status from the Service Module, please wait..

Image path = flash:c8xx_19xx_ap-k9w7-mx.acregr/c8xx_19xx_ap-k9w7-mx.acre
gr
System uptime = 0 days, 4 hours, 28 minutes, 5 seconds
Router#d was introduced for embedded wireless LAN access points on Integrated Services
Routers.
```

Managing the System Time and Date

You can manage the system time and date on the wireless device automatically, by using the Simple Network Time Protocol (SNTP), or manually, by setting the time and date on the wireless device.

Note For complete syntax and usage information for the commands used in this section, see *Cisco IOS Configuration Fundamentals Command Reference for Release 12.4*.

This section provides the following configuration information:

- Understanding Simple Network Time Protocol, page 312
- Configuring SNTP, page 312
- Configuring Time and Date Manually, page 312

Understanding Simple Network Time Protocol

Simple Network Time Protocol (SNTP) is a simplified, client-only version of NTP. SNTP can only receive the time from NTP servers; it cannot provide time services to other systems. SNTP typically provides time within 100 milliseconds of the accurate time, but it does not provide the complex filtering and statistical mechanisms of NTP.

You can configure SNTP to request and accept packets from configured servers or to accept NTP broadcast packets from any source. When multiple sources are sending NTP packets, the server with the best stratum is selected. Click this URL for more information on NTP and strata:

http://www.cisco.com/en/US/docs/ios/12_1/configfun/configuration/guide/fcd303.html#wp1001075

If multiple servers are at the same stratum, a configured server is preferred rather than a broadcast server. If multiple servers pass both tests, the first one to send a time packet is selected. SNTP chooses a new server only if the client stops receiving packets from the currently selected server, or if (according to the above criteria) SNTP discovers a better server.

Configuring SNTP

SNTP is disabled by default. To enable SNTP on the access point, use one or both of the commands listed in Table 2 in global configuration mode.

Table 2 SNTP Commands

Command	Purpose
sntp server {*address* | *hostname*} [**version** *number*]	Configures SNTP to request NTP packets from an NTP server.
sntp broadcast client	Configures SNTP to accept NTP packets from any NTP broadcast server.

Enter the **sntp server** command once for each NTP server. The NTP servers must be configured to respond to the SNTP messages from the access point.

If you enter both the **sntp server** command and the **sntp broadcast client** command, the access point accepts time from a broadcast server but prefers time from a configured server, if the strata are equal. To display information about SNTP, use the **show sntp** EXEC command.

Configuring Time and Date Manually

If no other source of time is available, you can manually configure the time and date after restarting the system. The time remains accurate until the next system restart. We recommend that you use manual configuration only as a last resort. If you have an outside source to which the wireless device can synchronize, you do not need to manually set the system clock.

This section contains the following configuration information:

- Setting the System Clock, page 313
- Displaying the Time and Date Configuration, page 313
- Configuring the Time Zone, page 314
- Configuring Summer Time (Daylight Saving Time), page 314

Setting the System Clock

If you have an outside source on the network that provides time services, such as an NTP server, you do not need to manually set the system clock.

To set the system clock, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **clock set** *hh*:*mm*:*ss day month year*

   or

   clock set *hh*:*mm*:*ss month day year*
2. **show running-config**
3. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**clock set** *hh*:*mm*:*ss day month year* or **clock set** *hh*:*mm*:*ss month day year*	Manually sets the system clock by using one of these formats: • For *hh*:*mm*:*ss*, specify the time in hours (24-hour format), minutes, and seconds. The time specified is relative to the configured time zone. • For *day*, specify the day by date in the month. • For *month*, specify the month by its full name. • For *year*, specify the year in four digits (no abbreviation).
Step 2	**show running-config**	Verifies your entries.
Step 3	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

This example shows how to manually set the system clock to 1:32 p.m. on July 23, 2001:

```
AP# clock set 13:32:00 23 July 2001
```

Displaying the Time and Date Configuration

To display the time and date configuration, use the **show clock** [**detail**] command in privileged EXEC mode.

The system clock keeps an *authoritative* flag that shows whether the time is authoritative (believed to be accurate). If the system clock has been set by a timing source such as NTP, the flag is set. If the time is not authoritative, it is used only for display purposes. Until the clock is authoritative and the *authoritative* flag is set, the flag prevents peers from synchronizing to the clock when the peers' time is invalid.

The symbol that precedes the **show clock** display has this meaning:

- *—Time is not authoritative.
- (blank)—Time is authoritative.
- .—Time is authoritative, but NTP is not synchronized.

Configuring the Time Zone

To manually configure the time zone, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **clock timezone** *zone hours-offset* [*minutes-offset*]
3. **end**
4. **show running-config**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**clock timezone** *zone hours-offset* [*minutes-offset*]	Sets the time zone. Because the wireless device keeps internal time in UTC[1], this command is used only for display purposes and when the time is manually set. • For *zone*, enter the name of the time zone to be displayed when standard time is in effect. The default is UTC. • For *hours-offset*, enter the hours offset from UTC. • (Optional) For *minutes-offset*, enter the minutes offset from UTC.
Step 3	**end**	Returns to privileged EXEC mode.
Step 4	**show running-config**	Verifies your entries.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

1. UTC = universal time coordinated

The *minutes-offset* variable in the **clock timezone** command in global configuration mode is available for situations where a local time zone is a percentage of an hour different from UTC. For example, the time zone for some sections of Atlantic Canada (AST) is UTC-3.5, where the 3 means 3 hours, and the .5 means 50 percent. In this case, the necessary command is **clock timezone AST -3 30**.

To set the time to UTC, use the **no clock timezone** command in global configuration mode.

Configuring Summer Time (Daylight Saving Time)

To configure summer time (daylight saving time) in areas where it starts and ends on a particular day of the week each year, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **clock summer-time** *zone* **recurring** [*week day month hh*:*mm week day month hh*:*mm* [*offset*]]
3. **end**

4. **show running-config**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**clock summer-time** *zone* **recurring** [*week day month hh*:*mm week day month hh*:*mm* [*offset*]]	Configures summer time to start and end on the specified days every year. Summer time is disabled by default. If you specify **clock summer-time** *zone* **recurring** without parameters, the summer time rules default to the United States rules. • For *zone*, specify the name of the time zone (for example, PDT) to be displayed when summer time is in effect. • (Optional) For *week*, specify the week of the month (1 to 5 or **last**). • (Optional) For *day*, specify the day of the week (for example, Sunday). • (Optional) For *month*, specify the month (for example, January). • (Optional) For *hh*:*mm*, specify the time (24-hour format) in hours and minutes. • (Optional) For *offset*, specify the number of minutes to add during summer time. The default is 60.
Step 3	**end**	Returns to privileged EXEC mode.
Step 4	**show running-config**	Verifies your entries.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

The first part of the **clock summer-time** global configuration command specifies when summer time begins, and the second part specifies when it ends. All times are relative to the local time zone. The start time is relative to standard time. The end time is relative to summer time. If the starting month is after the ending month, the system assumes that you are in the southern hemisphere.

This example shows how to specify that summer time starts on the first Sunday in April at 02:00 and ends on the last Sunday in October at 02:00:

```
AP(config)# clock summer-time PDT recurring 1 Sunday April 2:00 last Sunday October 2:00
```

If summer time in your area does not follow a recurring pattern (configure the exact date and time of the next summer time events), follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **clock summer-time** *zone* **date** [*month date year hh*:*mm month date year hh*:*mm* [*offset*]]

   or

   clock summer-time *zone* **date** [*date month year hh*:*mm date month year hh*:*mm* [*offset*]]
2. **end**
3. **show running-config**
4. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**clock summer-time** *zone* **date** [*month date year hh*:*mm month date year hh*:*mm* [*offset*]] or **clock summer-time** *zone* **date** [*date month year hh*:*mm date month year hh*:*mm* [*offset*]]	Configures summer time to start on the first date and end on the second date. Summer time is disabled by default. • For *zone*, specify the name of the time zone (for example, PDT) to be displayed when summer time is in effect. • (Optional) For *week*, specify the week of the month (1 to 5 or **last**). • (Optional) For *day*, specify the day of the week (for example, Sunday). • (Optional) For *month*, specify the month (for example, January). • (Optional) For *hh*:*mm*, specify the time (24-hour format) in hours and minutes. • (Optional) For *offset*, specify the number of minutes to add during summer time. The default is 60.
Step 3	**end**	Returns to privileged EXEC mode.
Step 4	**show running-config**	Verifies your entries.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

The first part of the **clock summer-time** global configuration command specifies when summer time begins, and the second part specifies when it ends. All times are relative to the local time zone. The start time is relative to standard time. The end time is relative to summer time. If the starting month is after the ending month, the system assumes that you are in the southern hemisphere.

To disable summer time, use the **no clock summer-time** command in global configuration mode.

This example shows how to set summer time to start on October 12, 2000, at 02:00, and end on April 26, 2001, at 02:00:

```
AP(config)# clock summer-time pdt date 12 October 2000 2:00 26 April 2001 2:00
```

Configuring a System Name and Prompt

You configure the system name on the wireless device to identify it. By default, the system name and prompt are *ap*.

If you have not configured a system prompt, the first 20 characters of the system name are used as the system prompt. A greater-than symbol (>) is appended. The prompt is updated whenever the system name changes, unless you manually configure the prompt by using the **prompt** command in global configuration mode.

Note For complete syntax and usage information for the commands used in this section, see *Cisco IOS Configuration Fundamentals Command Reference* and *Cisco IOS IP Addressing Services Command Reference*.

This section contains the following configuration information:

- Default System Name and Prompt Configuration, page 317
- Configuring a System Name, page 317
- Understanding DNS, page 318

Default System Name and Prompt Configuration

The default access point system name and prompt are *ap*.

Configuring a System Name

To manually configure a system name, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **hostname** *name*
3. **end**
4. **show running-config**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**hostname** *name*	Manually configures a system name. The default setting is *ap*. **Note** When you change the system name, the wireless device radios reset, and associated client devices disassociate and quickly reassociate. **Note** You can enter up to 63 characters for the system name. However, when the wireless device identifies itself to client devices, it uses only the first 15 characters in the system name. If it is important for client users to distinguish between devices, make sure that a unique portion of the system name appears in the first 15 characters.
Step 3	**end**	Returns to privileged EXEC mode.
Step 4	**show running-config**	Verifies your entries.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

When you set the system name, the name is also used as the system prompt.

To return to the default hostname, use the **no hostname** command in global configuration mode.

Understanding DNS

The DNS protocol controls the Domain Name System (DNS), a distributed database with which you can map hostnames to IP addresses. When you configure DNS on the wireless device, you can substitute the hostname for the IP address with all IP commands, such as **ping**, **telnet**, **connect**, and related Telnet support operations.

IP defines a hierarchical naming scheme that allows a device to be identified by its location or domain. Domain names are pieced together with periods (.) as the delimiting characters. For example, Cisco Systems is a commercial organization that IP identifies by a *com* domain name, so its domain name is *cisco.com*. A specific device in this domain, such as the File Transfer Protocol (FTP) system, is identified as *ftp.cisco.com*.

To keep track of domain names, IP has defined the concept of a domain name server, which holds a cache (or database) of names mapped to IP addresses. To map domain names to IP addresses, you must first identify the hostnames, specify the name server that is present on your network, and enable the DNS.

This section contains the following configuration information:

- Default DNS Configuration, page 319
- Setting Up DNS, page 319
- Displaying the DNS Configuration, page 320

Default DNS Configuration

Table 3 describes the default DNS configuration.

Table 3 Default DNS Configuration

Feature	Default Setting
DNS enable state	Disabled.
DNS default domain name	None configured.
DNS servers	No name server addresses are configured.

Setting Up DNS

To set up the wireless device to use the DNS, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **ip domain-name** *name*
3. **ip name-server** *server-address1* [*server-address2 ... server-address6*]
4. **ip domain-lookup**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**ip domain-name** *name*	Defines a default domain name that the software uses to complete unqualified hostnames (names without a dotted-decimal domain name). Do not include the initial period that separates an unqualified name from the domain name. At boot time, no domain name is configured. However, if the wireless device configuration comes from a BOOTP or DHCP server, then the default domain name might be set by the BOOTP or DHCP server (if the servers were configured with this information).
Step 3	**ip name-server** *server-address1* [*server-address2 ... server-address6*]	Specifies the address of one or more name servers to use for name and address resolution. You can specify up to six name servers. Separate server addresses with a space. The first server specified is the primary server. The wireless device sends DNS queries to the primary server first. If that query fails, the backup servers are queried.

	Command	Purpose
Step 4	**ip domain-lookup**	(Optional) Enables DNS-based hostname-to-address translation on the wireless device. This feature is enabled by default. If your network devices require connectivity with devices in networks for which you do not control name assignment, you can dynamically assign device names that uniquely identify your devices by using the global Internet naming scheme (DNS).
Step 5	**end**	Returns to privileged EXEC mode.
Step 6	**show running-config**	Verifies your entries.
Step 7	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

If you use the wireless device IP address as its hostname, the IP address is used and no DNS query occurs. If you configure a hostname that contains no periods (.), a period followed by the default domain name is appended to the hostname before the DNS query is made to map the name to an IP address. The default domain name is the value set by the **ip domain-name** command in global configuration mode. If there is a period (.) in the hostname, Cisco IOS software looks up the IP address without appending any default domain name to the hostname.

To remove a domain name, use the **no ip domain-name** *name* command in global configuration mode. To remove a name server address, use the **no ip name-server** *server-address* command in global configuration mode. To disable DNS on the wireless device, use the **no ip domain-lookup** command in global configuration mode.

Displaying the DNS Configuration

To display the DNS configuration information, use the **show running-config** command in privileged EXEC mode.

Note When DNS is configured on the wireless device, the **show running-config** command sometimes displays a server IP address instead of its name.

Creating a Banner

You can configure a message-of-the-day (MOTD) and a login banner. The MOTD banner appears on all connected terminals at login and is useful for sending messages that affect all network users (such as impending system shutdowns).

The login banner also appears on all connected terminals. It appears after the MOTD banner and appears before the login prompts appear.

Note For complete syntax and usage information for the commands used in this section, see *Cisco IOS Configuration Fundamentals Command Reference*.

This section contains the following configuration information:

- Default Banner Configuration, page 321
- Configuring a Message-of-the-Day Login Banner, page 321
- Configuring a Login Banner, page 322

Default Banner Configuration

The MOTD and login banners are not configured.

Configuring a Message-of-the-Day Login Banner

You can create a single-line or multiline message banner that appears on the screen when someone logs into the wireless device.

To configure an MOTD login banner, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **banner motd** *c message c*
3. **end**
4. **show running-config**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**banner motd** *c message c*	Specifies the message of the day. For *c*, enter the delimiting character of your choice, such as a pound sign (#), and press the **Return** key. The delimiting character signifies the beginning and end of the banner text. Characters after the ending delimiter are discarded. For *message*, enter a banner message up to 255 characters. You cannot use the delimiting character in the message.
Step 3	**end**	Returns to privileged EXEC mode.
Step 4	**show running-config**	Verifies your entries.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

To delete the MOTD banner, use the **no banner motd** command in global configuration mode.

The following is example shows how to configure a MOTD banner for the wireless device. The pound sign (#) is used as the beginning and ending delimiter:

```
AP(config)# banner motd #
```

```
This is a secure site. Only authorized users are allowed.
For access, contact technical support.
#
AP(config)#

This example shows the banner that results from the previous configuration:
Unix> telnet 172.2.5.4
Trying 172.2.5.4...
Connected to 172.2.5.4.
Escape character is '^]'.

This is a secure site. Only authorized users are allowed.
For access, contact technical support.

User Access Verification

Password:
```

Configuring a Login Banner

You can configure a login banner to appear on all connected terminals. This banner appears after the MOTD banner and appears before the login prompt appears.

To configure a login banner, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **banner login** *c message c*
3. **end**
4. **show running-config**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**banner login** *c message c*	Specifies the login message. For *c*, enter the delimiting character of your choice, such as a pound sign (#), and press the **Return** key. The delimiting character signifies the beginning and end of the banner text. Characters after the ending delimiter are discarded. For *message*, enter a login message up to 255 characters. You cannot use the delimiting character in the message.
Step 3	**end**	Returns to privileged EXEC mode.
Step 4	**show running-config**	Verifies your entries.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

To delete the login banner, use the **no banner login** command in global configuration mode.

The following example shows how to configure a login banner for the wireless device using the dollar sign ($) as the beginning and ending delimiter:

```
AP(config)# banner login $
Access for authorized users only. Please enter your username and password.
$
AP(config)#
```

Configuring Ethernet Speed and Duplex Settings

The Cisco 1941-W ISR interface supports only 1000 Mbps speed and duplex settings by default, and the interface is always up. When the wireless device receives inline power from a switch, any change in the speed or duplex settings that resets the Ethernet link reboots the wireless device.

Note The speed and duplex settings on the wireless device Ethernet port must match the Ethernet settings on the port to which the wireless device is connected. If you change the settings on the port to which the wireless device is connected, change the settings on the wireless device Ethernet port to match.

The Ethernet speed and duplex are set to **auto** by default. To configure Ethernet speed and duplex, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **interface fastethernet0**
3. **speed** {**10** | **100** | **auto**}
4. **duplex {auto | full | half}**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface fastethernet0**	Enters configuration interface mode.
Step 3	**speed** {**10** | **100** | **auto**}	Configures the Ethernet speed. we recommend that you use **auto**, the default setting.
Step 4	**duplex** {**auto** | **full** | **half**}	Configures the duplex setting. we recommend that you use **auto**, the default setting.
Step 5	**end**	Returns to privileged EXEC mode.

	Command	Purpose
Step 6	**show running-config**	Verifies your entries.
Step 7	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Configuring the Access Point for Wireless Network Management

You can enable the wireless device for wireless network management. The wireless network manager (WNM) manages the devices on your wireless LAN.

Enter the following command to configure the wireless device to interact with the WNM:

```
AP(config)# wlccp wnm ip address ip-address
```

Enter the following command to check the authentication status between the WDS access point and the WNM:

```
AP# show wlccp wnm status
```

Possible statuses are *not authenticated*, *authentication in progress*, *authentication fail*, *authenticated*, and *security keys setup*.

Configuring the Access Point for Local Authentication and Authorization

You can configure AAA to operate without a server by configuring the wireless device to implement AAA in local mode. The wireless device then handles authentication and authorization. No accounting is available in this configuration.

Note You can configure the wireless device as a local authenticator for 802.1x-enabled client devices to provide a backup for your main server or to provide authentication service on a network without a RADIUS server. See *Using the Access Point as a Local Authenticator* at Cisco.com for detailed instructions on configuring the wireless device as a local authenticator: http://www.cisco.com/en/US/docs/routers/access/wireless/software/guide/SecurityLocalAuthent.html.

To configure the wireless device for local AAA, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **aaa new-model**
3. **aaa authentication login default local**
4. **aaa authorization exec local**
5. **aaa authorization network local**
6. **username** *name* [**privilege** *level*] {**password** *encryption-type password*}
7. **end**

8. **show running-config**
9. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**aaa new-model**	Enables AAA.
Step 3	**aaa authentication login default local**	Sets the login authentication to use the local username database. The **default** keyword applies the local user database authentication to all interfaces.
Step 4	**aaa authorization exec local**	Configures user AAA authorization to determine whether the user is allowed to run an EXEC shell by checking the local database.
Step 5	**aaa authorization network local**	Configures user AAA authorization for all network-related service requests.
Step 6	**username** *name* [**privilege** *level*] {**password** *encryption-type password*}	Enters the local database, and establishes a username-based authentication system. Repeat this command for each user. • For *name*, specify the user ID as one word. Spaces and quotation marks are not allowed. • (Optional) For *level*, specify the privilege level that the user has after gaining access. The range is 0 to 15. Level 15 gives privileged EXEC mode access. Level 0 gives user EXEC mode access. • For *encryption-type*, enter **0** to specify that an unencrypted password follows. Enter **7** to specify that a hidden password follows. • For *password*, specify the password that the user must enter to gain access to the wireless device. The password must be from 1 to 25 characters long, can contain embedded spaces, and must be the last option specified in the **username** command. **Note** The characters TAB, ?, $, +, and [are invalid characters for passwords.
Step 7	**end**	Returns to privileged EXEC mode.
Step 8	**show running-config**	Verifies your entries.
Step 9	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

To disable AAA, use the **no aaa new-model** command in global configuration mode. To disable authorization, use the **no aaa authorization** {**network** | **exec**} *method1* command in global configuration mode.

Configuring the Authentication Cache and Profile

The authentication cache and profile feature allows the access point to cache the authentication and authorization responses for a user so that subsequent authentication and authorization requests do not need to be sent to the AAA server.

Note On the access point, this feature is supported only for Admin authentication.

The following commands that support this feature are included in Cisco IOS Release 12.3(7):

```
cache expiry
cache authorization profile
cache authentication profile
aaa cache profile
```

Note See *Cisco IOS Command Reference for Cisco Aironet Access Points and Bridges, Versions 12.4(10b)JA and 12.3(8)JEC* for information about these commands.

The following is a configuration example for an access point configured for Admin authentication using TACACS+ with the authorization cache enabled. Although this example is based on a TACACS server, the access point could be configured for Admin authentication using RADIUS:

```
version 12.3
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname ap
!
!
username Cisco password 7 123A0C041104
username admin privilege 15 password 7 01030717481C091D25
ip subnet-zero
!
!
aaa new-model
!
!
aaa group server radius rad_eap
server 192.168.134.229 auth-port 1645 acct-port 1646
!
aaa group server radius rad_mac
server 192.168.134.229 auth-port 1645 acct-port 1646
!
aaa group server radius rad_acct
server 192.168.134.229 auth-port 1645 acct-port 1646
!
aaa group server radius rad_admin
server 192.168.134.229 auth-port 1645 acct-port 1646
cache expiry 1
cache authorization profile admin_cache
cache authentication profile admin_cache
!
aaa group server tacacs+ tac_admin
server 192.168.133.231
cache expiry 1
cache authorization profile admin_cache
cache authentication profile admin_cache
```

```
!
aaa group server radius rad_pmip
!
aaa group server radius dummy
!
aaa authentication login default local cache tac_admin group tac_admin
aaa authentication login eap_methods group rad_eap
aaa authentication login mac_methods local
aaa authorization exec default local cache tac_admin group tac_admin
aaa accounting network acct_methods start-stop group rad_acct
aaa cache profile admin_cache
all
!
aaa session-id common
!
!
!
bridge irb
!
!
interface Dot11Radio0
no ip address
no ip route-cache
shutdown
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 Dot11Radio1
no ip address
no ip route-cache
shutdown
speed basic-6.0 9.0 basic-12.0 18.0 basic-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 192.168.133.207 255.255.255.0
no ip route-cache
!
ip http server
ip http authentication aaa
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
```

```
!
tacacs-server host 192.168.133.231 key 7 105E080A16001D1908
tacacs-server directed-request
radius-server attribute 32 include-in-access-req format %h
radius-server host 192.168.134.229 auth-port 1645 acct-port 1646 key 7 111918160405041E00
radius-server vsa send accounting
!
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 the Access Point to Provide DHCP Service

The following sections describe how to configure the wireless device to act as a DHCP server:

- Setting up the DHCP Server, page 328
- Monitoring and Maintaining the DHCP Server Access Point, page 330

Setting up the DHCP Server

By default, access points are configured to receive IP settings from a DHCP server on your network. You can also configure an access point to act as a DHCP server to assign IP settings to devices on both wired and wireless LANs.

Note When you configure the access point as a DHCP server, it assigns IP addresses to devices on its subnet. The devices communicate with other devices on the subnet but not beyond it. If data needs to be passed beyond the subnet, you must assign a default router. The IP address of the default router should be on the same subnet as the access point configured as the DHCP server.

For detailed information on DHCP-related commands and options, see the DHCP part in *Cisco IOS IP Addressing Services Configuration Guide, Release 12.4*. Click this URL to browse to the DHCP part:

http://www.cisco.com/en/US/docs/ios/ipaddr/configuration/guide/iad_dhcp_rdmp_ps6350_TSD_Products_Configuration_Guide_Chapter.html

To configure an access point to provide DHCP service and to specify a default router, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **ip dhcp excluded-address** *low_address* [*high_address*]
3. **ip dhcp pool** *pool_name*
4. **network** *subnet_number* [*mask* | *prefix-length*]
5. **lease** {*days* [*hours*] [*minutes*] | **infinite**}
6. **default-router** *address* [*address2 ... address 8*]
7. **end**
8. **show running-config**
9. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**ip dhcp excluded-address** *low_address* [*high_address*]	Excludes the wireless device IP address from the range of addresses that the wireless device assigns. Enter the IP address in four groups of characters, such as 10.91.6.158. The wireless device assumes that all IP addresses in a DHCP address pool subnet are available for assigning to DHCP clients. You must specify the IP addresses that the DHCP server should not assign to clients. (Optional) To enter a range of excluded addresses, enter the address at the low end of the range, followed by the address at the high end of the range.
Step 3	**ip dhcp pool** *pool_name*	Creates a name for the pool of IP addresses that the wireless device assigns in response to DHCP requests, and enters DHCP configuration mode.
Step 4	**network** *subnet_number* [*mask* | *prefix-length*]	Assigns the subnet number for the address pool. The wireless device assigns IP addresses within this subnet. (Optional) Assigns a subnet mask for the address pool, or specifies the number of bits that compose the address prefix. The prefix is an alternative way of assigning the network mask. The prefix length must be preceded by a forward slash (/).
Step 5	**lease** {*days* [*hours*] [*minutes*] | **infinite**}	Configures the duration of the lease for IP addresses assigned by the wireless device. • days—configure the lease duration in number of days • (optional) hours—configure the lease duration in number of hours • (optional) minutes—configure the lease duration in number of minutes • infinite—set the lease duration to infinite

	Command	Purpose
Step 6	**default-router** *address* [*address2 ... address 8*]	Specifies the IP address of the default router for DHCP clients on the subnet. One IP address is required; however, you can specify up to eight addresses in one command line.
Step 7	**end**	Returns to privileged EXEC mode.
Step 8	**show running-config**	Verifies your entries.
Step 9	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Use the **no** forms of these commands to return to default settings.

The following example shows how to configure the wireless device as a DHCP server, how to exclude a range of IP address, and how to assign a default router:

```
AP# configure terminal
AP(config)# ip dhcp excluded-address 172.16.1.1 172.16.1.20
AP(config)# ip dhcp pool wishbone
AP(dhcp-config)# network 172.16.1.0 255.255.255.0
AP(dhcp-config)# lease 10
AP(dhcp-config)# default-router 172.16.1.1
AP(dhcp-config)# end
```

Monitoring and Maintaining the DHCP Server Access Point

The following sections describe commands you can use to monitor and maintain the DHCP server access point:

- show Commands, page 330
- clear Commands, page 331
- debug Command, page 331

show Commands

To display information about the wireless device as DHCP server, enter the commands in Table 4, in privileged EXEC mode.

Table 4 Show Commands for DHCP Server

Command	Purpose
show ip dhcp conflict [*address*]	Displays a list of all address conflicts recorded by a specific DHCP Server. Enter the wireless device IP address to show conflicts recorded by the wireless device.
show ip dhcp database [*url*]	Displays recent activity on the DHCP database. **Note** Use this command in privileged EXEC mode.
show ip dhcp server statistics	Displays count information about server statistics and messages sent and received.

clear Commands

To clear DHCP server variables, use the commands in Table 5, in privileged EXEC mode.

Table 5 Clear Commands for DHCP Server

Command	Purpose
clear ip dhcp binding {*address* | *}*	Deletes an automatic address binding from the DHCP database. Specifying the address argument clears the automatic binding for a specific (client) IP address. Specifying an asterisk (*) clears all automatic bindings.
clear ip dhcp conflict {*address* | *}*	Clears an address conflict from the DHCP database. Specifying the address argument clears the conflict for a specific IP address. Specifying an asterisk (*) clears conflicts for all addresses.
clear ip dhcp server statistics	Resets all DHCP server counters to 0.

debug Command

To enable DHCP server debugging, use the following command in privileged EXEC mode:

debug ip dhcp server {**events** | **packets** | **linkage**}

Use the **no** form of the command to disable debugging for the wireless device DHCP server.

Configuring the Access Point for Secure Shell

This section describes how to configure the Secure Shell (SSH) feature.

Note For complete syntax and usage information for the commands used in this section, see the "Secure Shell Commands" section in *Cisco IOS Security Command Reference for Release 12.4.*

Understanding SSH

SSH is a protocol that provides a secure, remote connection to a Layer 2 or Layer 3 device. There are two versions of SSH: SSH version 1 and SSH version 2. This software release supports both SSH versions. If you do not specify the version number, the access point defaults to version 2.

SSH provides more security for remote connections than Telnet by providing strong encryption when a device is authenticated. The SSH feature has an SSH server and an SSH integrated client. The client supports the following user authentication methods:

- RADIUS (for more information, see the "Controlling Access Point Access with RADIUS" section on page 301)
- Local authentication and authorization (for more information, see the "Configuring the Access Point for Local Authentication and Authorization" section on page 324)

For more information about SSH, see Part 5, "Other Security Features" in the *Cisco IOS Security Configuration Guide for Release 12.4.*

Note The SSH feature in this software release does not support IP Security (IPsec).

Configuring SSH

Before configuring SSH, download the cryptographic software image from Cisco.com. For more information, see the release notes for this release.

For information about configuring SSH and displaying SSH settings, see Part 6, "Other Security Features" in the *Cisco IOS Security Configuration Guide for Release 12.4*, which is available at Cisco.com at the following link:

http://www.cisco.com/en/US/docs/ios/security/configuration/guide/12_4/sec_12_4_book.html

Configuring Client ARP Caching

You can configure the wireless device to maintain an address resolution protocol (ARP) cache for associated client devices. Maintaining an ARP cache on the wireless device reduces the traffic load on your wireless LAN. ARP caching is disabled by default.

This section contains this information:

- Understanding Client ARP Caching, page 332
- Configuring ARP Caching, page 333

Understanding Client ARP Caching

ARP caching on the wireless device reduces the traffic on your wireless LAN by stopping ARP requests for client devices at the wireless device. Instead of forwarding ARP requests to client devices, the wireless device responds to requests on behalf of associated client devices.

When ARP caching is disabled, the wireless device forwards all ARP requests through the radio port to associated clients. The client that receives the ARP request responds. When ARP caching is enabled, the wireless device responds to ARP requests for associated clients and does not forward requests to clients. When the wireless device receives an ARP request for an IP address not in the cache, the wireless device drops the request and does not forward it. In its beacon, the wireless device includes an information element to alert client devices that they can safely ignore broadcast messages to increase battery life.

Optional ARP Caching

When a non-Cisco client device is associated to an access point and is not passing data, the wireless device might not know the client IP address. If this situation occurs frequently on your wireless LAN, you can enable optional ARP caching. When ARP caching is optional, the wireless device responds on behalf of clients with IP addresses known to the wireless device but forwards out of its radio port any ARP requests addressed to unknown clients. When the wireless device learns the IP addresses for all associated clients, it drops ARP requests not directed to its associated clients.

Configuring ARP Caching

To configure the wireless device to maintain an ARP cache for associated clients, follow these steps, beginning in privileged EXEC mode.

SUMMARY STEPS

1. **configure terminal**
2. **dot11 arp-cache** [**optional**]
3. **end**
4. **show running-config**
5. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**dot11 arp-cache** [**optional**]	Enables ARP caching on the wireless device. • (Optional) Use the **optional** keyword to enable ARP caching only for the client devices whose IP addresses are known to the wireless device.
Step 3	**end**	Returns to privileged EXEC mode.
Step 4	**show running-config**	Verifies your entries.
Step 5	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

The following example shows how to configure ARP caching on an access point:

```
AP# configure terminal
AP(config)# dot11 arp-cache
AP(config)# end
```

Configuring Multiple VLAN and Rate Limiting for Point-to-Multipoint Bridging

This feature modifies the way that point-to-multipoint bridging can be configured to operate on multiple VLANs with the ability to control traffic rates on each VLAN.

Note A rate-limiting policy can be applied only to Fast Ethernet ingress ports on non-root bridges.

In a typical scenario, multiple-VLAN support permits users to set up point-to-multipoint bridge links with remote sites, with each remote site on a separate VLAN. This configuration provides the capability for separating and controlling traffic to each site. Rate limiting ensures that no remote site consumes more than a specified amount of the entire link bandwidth. Only uplink traffic can be controlled by using the Fast Ethernet ingress ports of non-root bridges.

Using the class-based policing feature, you can specify the rate limit and apply it to the ingress of the Ethernet interface of a non-root bridge. Applying the rate at the ingress of the Ethernet interface ensures that all incoming Ethernet packets conform to the configured rate.

Cisco IOS CLI for Initial Configuration

The following sections describe how to perform the initial configuration using the Cisco Internet Operating System (IOS) command line interface (CLI).

- Prerequisites for Initial Software Configuration Using the Cisco IOS CLI, page A-1
- Using the Cisco IOS CLI to Perform Initial Configuration, page A-2

Note We recommend using Cisco Configuration Professional Express web-based application to configure the initial router settings. See *Cisco Configuration Professional Express User Guide* at Cisco.com for detailed instructions, http://www.cisco.com/en/US/docs/net_mgmt/cisco_configuration_professional_express/v1_4/olh/ccp_express.html

Initial Configuration of the Wireless Access Point on Cisco 1941W Router

The embedded wireless access point (AP) runs its own version of Cisco Internet Operating System (IOS) software. Use Cisco Configuration Professional Express to perform the initial configuration of the access point software. For information on how to configure additional wireless parameters see the "Configuring the Wireless Device" module in this guide.

Prerequisites for Initial Software Configuration Using the Cisco IOS CLI

Follow the instructions in the hardware installation guide for your router to install the chassis, connect cables, and supply power to the hardware.

Timesaver Before supplying power to the router, disconnect all WAN cables from the router to keep it from trying to run the AutoInstall process. The router may try to run AutoInstall if you power it up while there is a WAN connection on both ends and the router does not have a valid configuration file stored in NVRAM (for instance, when you add a new interface). It can take several minutes for the router to determine that AutoInstall is not connected to a remote TCP/IP host.

Using the Cisco IOS CLI to Perform Initial Configuration

This section contains the following procedures:

- Configuring the Router Hostname, page A-2 (Optional)
- Configuring the Enable and Enable Secret Passwords, page A-3 (Required)
- Configuring the Console Idle Privileged EXEC Timeout, page A-5 (Optional)
- Configuring Gigabit Ethernet Interfaces, page A-6 (Required)
- Specifying a Default Route or Gateway of Last Resort, page A-8 (Required)
- Configuring Virtual Terminal Lines for Remote Console Access, page A-11 (Required)
- Configuring the Auxiliary Line, page A-13 (Optional)
- Verifying Network Connectivity, page A-14 (Required)
- Saving Your Router Configuration, page A-16 (Required)
- Saving Backup Copies of Configuration and System Image, page A-16 (Optional)

Configuring the Router Hostname

The hostname is used in CLI prompts and default configuration filenames. If you do not configure the router hostname, the router uses the factory-assigned default hostname "Router."

Do not expect capitalization and lower casing to be preserved in the hostname. Uppercase and lowercase characters are treated as identical by many Internet software applications. It may seem appropriate to capitalize a name as you would ordinarily do, but conventions dictate that computer names appear in all lowercase characters. For more information, see RFC 1178, *Choosing a Name for Your Computer.*

The name must also follow the rules for Advanced Research Projects Agency Network (ARPANET) hostnames. They must start with a letter, end with a letter or digit, and have as interior characters only letters, digits, and hyphens. Names must be 63 characters or fewer. For more information, see RFC 1035, *Domain Names—Implementation and Specification*.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **hostname** *name*
4. Verify that the router prompt displays your new hostname.
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**hostname** *name* **Example:** `Router(config)# hostname myrouter`	Specifies or modifies the hostname for the network server.
Step 4	Verify that the router prompt displays your new hostname. **Example:** `myrouter(config)#`	—
Step 5	**end** **Example:** `myrouter# end`	(Optional) Returns to privileged EXEC mode.

Configuring the Enable and Enable Secret Passwords

To provide an additional layer of security, particularly for passwords that cross the network or are stored on a TFTP server, you can use either the **enable password** command or **enable secret** command. Both commands accomplish the same thing—they allow you to establish an encrypted password that users must enter to access privileged EXEC (enable) mode.

We recommend that you use the **enable secret** command because it uses an improved encryption algorithm. Use the **enable password** command only if you boot an older image of the Cisco IOS software or if you boot older boot ROMs that do not recognize the **enable secret** command.

For more information, see the "Configuring Passwords and Privileges" chapter in *Cisco IOS Security Configuration Guide*. Also see the *Cisco IOS Password Encryption Facts* tech note and the *Improving Security on Cisco Routers* tech note.

Restrictions

If you configure the **enable secret** command, it takes precedence over the **enable password** command; the two commands cannot be in effect simultaneously.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **enable password** *password*
4. **enable secret** *password*
5. **end**
6. **enable**
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**enable password** *password* **Example:** `Router(config)# enable password pswd2`	(Optional) Sets a local password to control access to various privilege levels. • We recommend that you perform this step only if you boot an older image of the Cisco IOS software or if you boot older boot ROMs that do not recognize the **enable secret** command.
Step 4	**enable secret** *password* **Example:** `Router(config)# enable secret greentree`	Specifies an additional layer of security over the **enable password** command. • Do not use the same password that you entered in Step 3.
Step 5	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 6	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Verify that your new enable or enable secret password works.
Step 7	**end** **Example:** `Router(config)# end`	(Optional) Returns to privileged EXEC mode.

Configuring the Console Idle Privileged EXEC Timeout

This section describes how to configure the console line's idle privileged EXEC timeout. By default, the privileged EXEC command interpreter waits 10 minutes to detect user input before timing out.

When you configure the console line, you can also set communication parameters, specify autobaud connections, and configure terminal operating parameters for the terminal that you are using. For more information on configuring the console line, see the "Configuring Operating Characteristics for Terminals" chapter in *Cisco IOS Configuration Fundamentals Configuration Guide*, and "Troubleshooting, Fault Management, and Logging" chapter in the *Cisco IOS Network Management Configuration Guide*.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line console 0**
4. **exec-timeout** *minutes* [*seconds*]
5. **end**
6. **show running-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**line console 0** **Example:** `Router(config)# line console 0`	Configures the console line and starts the line configuration command collection mode.
Step 4	**exec-timeout** *minutes* [*seconds*] **Example:** `Router(config-line)# exec-timeout 0 0`	Sets the idle privileged EXEC timeout, which is the interval that the privileged EXEC command interpreter waits until user input is detected. • The example shows how to specify no timeout. Setting the exec-timeout value to 0 causes the router to never log out once logged in. This could have security implications if you leave the console without manually logging out using the disable command.

	Command or Action	Purpose
Step 5	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 6	**show running-config** **Example:** `Router(config)# show running-config`	Displays the running configuration file. • Verify that you properly configured the idle privileged EXEC timeout.

Examples

The following example shows how to set the console idle privileged EXEC timeout to 2 minutes 30 seconds:

```
line console
 exec-timeout 2 30
```

The following example shows how to set the console idle privileged EXEC timeout to 10 seconds:

```
line console
 exec-timeout 0 10
```

Configuring Gigabit Ethernet Interfaces

This sections shows how to assign an IP address and interface description to an Ethernet interface on your router.

For comprehensive configuration information on Gigabit Ethernet interfaces, see the "Configuring LAN Interfaces" chapter of *Cisco IOS Interface and Hardware Component Configuration Guide*, http://www.cisco.com/en/US/docs/ios/12_2/interface/configuration/guide/icflanin.html

For information on interface numbering, see *Software Configuration Guide* for your router.

SUMMARY STEPS

1. **enable**
2. **show ip interface brief**
3. **configure terminal**
4. **interface gigabitethernet 0/***port*
5. **description** *string*
6. **ip address** *ip-address mask*
7. **no shutdown**
8. **end**
9. **show ip interface brief**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show ip interface brief** **Example:** `Router# show ip interface brief`	Displays a brief status of the interfaces that are configured for IP. • Learn which type of Ethernet interface is on your router.
Step 3	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 4	**interface gigabitethernet 0/***port* **Example:** `Router(config)# interface gigabitethernet 0/0`	Specifies the gigabit Ethernet interface and enters interface configuration mode. **Note** For information on interface numbering, see *Software Configuration Guide*.
Step 5	**description** *string* **Example:** `Router(config-if)# description GE int to 2nd floor south wing`	(Optional) Adds a description to an interface configuration. • The description helps you remember what is attached to this interface. The description can be useful for troubleshooting.
Step 6	**ip address** *ip-address mask* **Example:** `Router(config-if)# ip address 172.16.74.3 255.255.255.0`	Sets a primary IP address for an interface.
Step 7	**no shutdown** **Example:** `Router(config-if)# no shutdown`	Enables an interface.
Step 8	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 9	**show ip interface brief** **Example:** `Router# show ip interface brief`	Displays a brief status of the interfaces that are configured for IP. • Verify that the Ethernet interfaces are up and configured correctly.

Examples

Configuring the GigabitEthernet Interface: Example

```
!
interface GigabitEthernet0/0
 description GE int to HR group
 ip address 172.16.3.3 255.255.255.0
 duplex auto
 speed auto
 no shutdown
!
```

Sample Output for the show ip interface brief Command

```
Router# show ip interface brief

Interface                  IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0            172.16.3.3      YES NVRAM  up                    up
GigabitEthernet0/1            unassigned      YES NVRAM  administratively down down
Router#
```

Specifying a Default Route or Gateway of Last Resort

This section describes how to specify a default route with IP routing enabled. For alternative methods of specifying a default route, see the *Configuring a Gateway of Last Resort Using IP Commands* tech note.

The Cisco IOS software uses the gateway (router) of last resort if it does not have a better route for a packet and if the destination is not a connected network. This section describes how to select a network as a default route (a candidate route for computing the gateway of last resort). The way in which routing protocols propagate the default route information varies for each protocol.

For comprehensive configuration information about IP routing and IP routing protocols, see *Cisco IOS IP Configuration Guide*. In particular, see the "Configuring IP Addressing" chapter and all "Part 2: IP Routing Protocols" chapters.

IP Routing

You can configure integrated routing and bridging (IRB) so the router can route and bridge simultaneously. The router will act as an IP host on the network whether routing is enabled or not. To read more about IRB see the following URL at Cisco.com:
http://www.cisco.com/en/US/tech/tk389/tk815/tk855/tsd_technology_support_sub-protocol_home.html

IP routing is automatically enabled in the Cisco IOS software. When IP routing is configured, the system will use a configured or learned route to forward packets, including a configured default route.

Note This task section does not apply when IP routing is disabled. To specify a default route when IP routing is disabled, see the *Configuring a Gateway of Last Resort Using IP Commands* tech note at Cisco.com.

Default Routes

A router might not be able to determine the routes to all other networks. To provide complete routing capability, the common practice is to use some routers as smart routers and give the remaining routers default routes to the smart router. (Smart routers have routing table information for the entire internetwork.) These default routes can be passed along dynamically, or can be configured into the individual routers.

Most dynamic interior routing protocols include a mechanism for causing a smart router to generate dynamic default information that is then passed along to other routers.

Default Network

If a router has an interface that is directly connected to the specified default network, the dynamic routing protocols running on the router will generate or source a default route. In the case of RIP, the router will advertise the pseudo network 0.0.0.0. In the case of IGRP, the network itself is advertised and flagged as an exterior route.

A router that is generating the default for a network also may need a default of its own. One way a router can generate its own default is to specify a static route to the network 0.0.0.0 through the appropriate device.

Gateway of Last Resort

When default information is being passed along through a dynamic routing protocol, no further configuration is required. The system periodically scans its routing table to choose the optimal default network as its default route. In the case of RIP, there is only one choice, network 0.0.0.0. In the case of IGRP, there might be several networks that can be candidates for the system default. The Cisco IOS software uses both administrative distance and metric information to determine the default route (gateway of last resort). The selected default route appears in the gateway of last resort display of the **show ip route** EXEC command.

If dynamic default information is not being passed to the software, candidates for the default route are specified with the **ip default-network** global configuration command. In this usage, the **ip default-network** command takes an unconnected network as an argument. If this network appears in the routing table from any source (dynamic or static), it is flagged as a candidate default route and is a possible choice as the default route.

If the router has no interface on the default network, but does have a route to it, it considers this network as a candidate default path. The route candidates are examined and the best one is chosen, based on administrative distance and metric. The gateway to the best default path becomes the gateway of last resort.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip routing**
4. **ip route** *dest-prefix mask next-hop-ip-address* [*admin-distance*] [**permanent**]
5. **ip default-network** *network-number*
   or
   ip route *dest-prefix mask next-hop-ip-address*

6. **end**
7. **show ip route**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip routing** **Example:** `Router(config)# ip routing`	Enables IP routing.
Step 4	**ip route** *dest-prefix mask next-hop-ip-address* [*admin-distance*] [**permanent**] **Example:** `Router(config)# ip route 192.168.24.0 255.255.255.0 172.28.99.2`	Establishes a static route.

Step 5	**ip default-network** *network-number*
	or
	ip route *dest-prefix mask next-hop-ip-address*
	
	Example:
	`Router(config)# ip default-network 192.168.24.0`
	
	Example:
	`Router(config)# ip route 0.0.0.0 0.0.0.0 172.28.99.1`
		Selects a network as a candidate route for computing the gateway of last resort.
		Creates a static route to network 0.0.0.0 0.0.0.0 for computing the gateway of last resort.

Step 6	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 7	**show ip route** **Example:** `Router# show ip route`	Displays the current routing table information. • Verify that the gateway of last resort is set.

Examples

Specifying a Default Route: Example

```
!
ip routing
!
ip route 192.168.24.0 255.255.255.0 172.28.99.2
!
ip default-network 192.168.24.0
!
```

Sample Output for the show ip route Command

```
Router# show ip route

Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default

Gateway of last resort is 172.28.99.2 to network 192.168.24.0

     172.24.0.0 255.255.255.0 is subnetted, 1 subnets
C       172.24.192.0 is directly connected, GigaEthernet0
S       172.24.0.0 255.255.0.0 [1/0] via 172.28.99.0
S*    192.168.24.0 [1/0] via 172.28.99.2
     172.16.0.0 255.255.255.0 is subnetted, 1 subnets
C       172.16.99.0 is directly connected, GigaEthernet1
Router#
```

Configuring Virtual Terminal Lines for Remote Console Access

Virtual terminal (vty) lines are used to allow remote access to the router. This section shows you how to configure the virtual terminal lines with a password, so that only authorized users can remotely access the router.

The router has five virtual terminal lines by default. However, you can create additional virtual terminal lines as described in the Cisco IOS Terminal Services Configuration Guide, Release 12.4. See the *Configuring Terminal Operating Characteristics for Dial-In Sessions* section.

Line passwords and password encryption is described in the Cisco IOS Security Configuration Guide, Release 12.4. See the Security with Passwords, Privilege Levels, and Login Usernames for CLI Sessions on Networking Devices section. If you want to secure the vty lines with an access list, see Access Control Lists: Overview and Guidelines. Also see the *Cisco IOS Password Encryption Facts* tech note.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line vty** *line-number* [*ending-line-number*]
4. **password** *password*
5. **login**
6. **end**
7. **show running-config**
8. From another network device, attempt to open a Telnet session to the router.

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**line vty** *line-number* [*ending-line-number*] **Example:** `Router(config)# line vty 0 4`	Starts the line configuration command collection mode for the virtual terminal lines (vty) for remote console access. • Make sure that you configure all vty lines on your router. **Note** To verify the number of vty lines on your router, use the **line vty ?** command.
Step 4	**password** *password* **Example:** `Router(config-line)# password guessagain`	Specifies a password on a line.
Step 5	**login** **Example:** `Router(config-line)# login`	Enables password checking at login.
Step 6	**end** **Example:** `Router(config-line)# end`	Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 7	**show running-config** **Example:** `Router# show running-config`	Displays the running configuration file. • Verify that you properly configured the virtual terminal lines for remote access.

Step 8	From another network device, attempt to open a Telnet session to the router.
	
	Example:
	`Router# 172.16.74.3`
	`Password:`
		Verifies that you can remotely access the router and that the virtual terminal line password is correctly configured.

Examples

The following example shows how to configure virtual terminal lines with a password:

```
!
line vty 0 4
 password guessagain
 login
!
```

What to Do Next

After you configure the vty lines, follow these steps:

- (Optional) To encrypt the virtual terminal line password, see the "Configuring Passwords and Privileges" chapter in *Cisco IOS Security Configuration Guide*. Also see the *Cisco IOS Password Encryption Facts* tech note.
- (Optional) To secure the VTY lines with an access list, see "Part 3: Traffic Filtering and Firewalls" in the *Cisco IOS Security Configuration Guide*.

Configuring the Auxiliary Line

This section describes how to enter line configuration mode for the auxiliary line. How you configure the auxiliary line depends on your particular implementation of the auxiliary (AUX) port. See the following documents for information on configuring the auxiliary line:

Configuring a Modem on the AUX Port for EXEC Dialin Connectivity, tech note
http://www.cisco.com/en/US/tech/tk801/tk36/technologies_tech_note09186a0080094bbc.shtml

Configuring Dialout Using a Modem on the AUX Port, sample configuration
http://www.cisco.com/en/US/tech/tk801/tk36/technologies_configuration_example09186a0080094579.shtml

Configuring AUX-to-AUX Port Async Backup with Dialer Watch, sample configuration
http://www.cisco.com/en/US/tech/tk801/tk36/technologies_configuration_example09186a0080093d2b.shtml

Modem-Router Connection Guide, tech note
http://www.cisco.com/en/US/tech/tk801/tk36/technologies_tech_note09186a008009428b.shtml

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line aux 0**
4. See the tech notes and sample configurations to configure the line for your particular implementation of the AUX port.

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**line aux 0** **Example:** `Router(config)# line aux 0`	Starts the line configuration command collection mode for the auxiliary line.
Step 4	See the tech notes and sample configurations to configure the line for your particular implementation of the AUX port.	—

Verifying Network Connectivity

This section describes how to verify network connectivity for your router.

Prerequisites

- Complete all previous configuration tasks in this document.
- The router must be connected to a properly configured network host.

SUMMARY STEPS

1. **enable**
2. **ping** [*ip-address* | *hostname*]
3. **telnet** {*ip-address* | *hostname*}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**ping** [*ip-address* | *hostname*] **Example:** `Router# ping 172.16.74.5`	Diagnoses initial network connectivity. • To verify connectivity, ping the next hop router or connected host for each configured interface to.
Step 3	**telnet** {*ip-address* | *hostname*} **Example:** `Router# telnet 10.20.30.40`	Logs in to a host that supports Telnet. • If you want to test the vty line password, perform this step from a different network device, and use your router's IP address.

Examples

The following display shows sample output for the ping command when you ping the IP address 192.168.7.27:

```
Router# ping

Protocol [ip]:
Target IP address: 192.168.7.27
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.7.27, timeout is 2 seconds:
!!!!!
Success rate is 100 percent, round-trip min/avg/max = 1/2/4 ms
```

The following display shows sample output for the ping command when you ping the IP hostname *username1*:

```
Router# ping username1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.7.27, timeout is 2 seconds:
!!!!!
Success rate is 100 percent, round-trip min/avg/max = 1/3/4 ms
```

Saving Your Router Configuration

This section describes how to avoid losing your configuration at the next system reload or power cycle by saving the running configuration to the startup configuration in NVRAM. The NVRAM provides 256KB of storage on the router.

SUMMARY STEPS

1. **enable**
2. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	Saves the running configuration to the startup configuration.

Saving Backup Copies of Configuration and System Image

To aid file recovery and minimize downtime in case of file corruption, we recommend that you save backup copies of the startup configuration file and the Cisco IOS software system image file on a server.

SUMMARY STEPS

1. **enable**
2. **copy nvram:startup-config** {**ftp:** | **rcp:** | **tftp:**}
3. **show {flash0 | flash1}:**
4. **copy {flash0 | flash1}:** {**ftp:** | **rcp:** | **tftp:**}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**copy nvram:startup-config** {**ftp:** | **rcp:** | **tftp:**} **Example:** `Router# copy nvram:startup-config ftp:`	Copies the startup configuration file to a server. • The configuration file copy can serve as a backup copy. • Enter the destination URL when prompted.
Step 3	**show {flash0 | flash1}:** **Example:** `Router# show {flash0|flash1}:`	Displays the layout and contents of a flash memory file system. • Learn the name of the system image file.
Step 4	**copy {flash0 | flash1}:** {**ftp:** | **rcp:** | **tftp:**} **Example:** `Router# copy {flash0|flash1}: ftp:`	Copies a file from flash memory to a server. • Copy the system image file to a server to serve as a backup copy. • Enter the filename and destination URL when prompted.

Examples

Copying the Startup Configuration to a TFTP Server: Example

The following example shows the startup configuration being copied to a TFTP server:

```
Router# copy nvram:startup-config tftp:

Remote host[]? 172.16.101.101

Name of configuration file to write [rtr2-confg]? <cr>
Write file rtr2-confg on host 172.16.101.101?[confirm] <cr>
![OK]
```

Copying from Flash Memory to a TFTP Server: Example

The following example shows the use of the **show {flash0|flash1}:** command in privileged EXEC to learn the name of the system image file and the use of the **copy {flash0|flash1}: tftp:** privileged EXEC command to copy the system image (c3900-2is-mz) to a TFTP server. The router uses the default username and password.

```
Router# show {flash0|flash1}:

System flash directory:
File Length Name/status
1 4137888 c3900-c2is-mz
[4137952 bytes used, 12639264 available, 16777216 total]
16384K bytes of processor board System flash (Read/Write)\

Router# copy {flash0|flash1}: tftp:

IP address of remote host [255.255.255.255]? 172.16.13.110
```

```
filename to write on tftp host? c3600-c2is-mz
writing c3900-c2is-mz !!!!...
successful ftp write.
```

Using CompactFlash Memory Cards

Cisco 3900 Series, 2900 Series, and 1900 Series Integrated Services Routers (ISR) use Advanced Capability CompactFlash (CF) external memory to store the system image, configuration files, and some software data files. CF supports True IDE mode and Multi-Word DMA mode.

The following sections explain how to manage directories and files on the CF:

- Requirements and Restrictions, page B-1
- Online Insertion and Removal, page B-2
- How to Format CompactFlash Memory Cards, page B-2
- File Operations on CompactFlash Memory Cards, page B-4
- Directory Operations on a CompactFlash Memory Card, page B-7

Requirements and Restrictions

CompactFlash Support

- Only Advanced Capability CF purchased from Cisco operate in Cisco 3900 Series, 2900 Series, and 1900 Series Integrated Services Routers.
- Legacy CF will not operate in Cisco 3900 Series, 2900 Series, and 1900 Series Integrated Services Routers. When legacy CF is inserted, the following error message appears:

```
WARNING: Unsupported compact flash detected. Use of this card during normal operation
can impact and severely degrade performance of the system. Please use supported
compact flash cards only.
```

Formatting CompactFlash

- Only Class C file systems are supported on Cisco Compact Flash (CF).
- We recommend that you format new CF to initialize a new flash file system. Proper formatting lets ROM monitor recognize and boot the flash memory. The CF can be formatted on an ISR, and files copied to or from any PC that is equipped with a CF memory reader. If you use a PC to format the CF, use the Microsoft File Allocation Table (FAT32) file system.

CompactFlash Slots and Files

- Cisco 3900 series, 2900 series, and 1900 series ISRs have 2 external CF slots.
- CF in Slot0 can store the system image, configuration, and data files. The CF must be present in this slot for the router to boot and perform normal file operations.

Table B-1 Compact Flash Slot Numbering and Naming

Slot Number	CF Filenames	Size[1]
Slot0[2]	`flash0:`	`256MB`
Slot1	`flash1:`	`0`

1. The maximum storage capacity for the CF in Slot0 and Slot1 is 4GB.
2. Slot 0 is the default CF slot. CF in slot0 can store system image, configuration, and data files. CF must be present in this slot for the router to boot and perform normal file operations.

Online Insertion and Removal

Online insertion and removal (OIR) is a feature that allows you to replace CF memory cards without turning off the router and without affecting the operation of other interfaces. OIR of CF memory cards provides uninterrupted operation to network users, maintains routing information, and ensures session preservation.

Caution The external CF memory card should not be removed if the flash memory busy "CF" LED on the router is blinking, because this indicates that the software is accessing the CF memory card. Removing the CF memory card may disrupt the network, because some software features use the CF memory card to store tables and other important data.

For instructions on inserting, removing, and replacing the external CF memory card, see the hardware installation guide for your router.

How to Format CompactFlash Memory Cards

This section contains the following procedures:

- Determining the File System on a CompactFlash Memory Card, page B-2
- Formatting CompactFlash Memory as a Class C File System, page B-3

Determining the File System on a CompactFlash Memory Card

To determine the file system of a CF memory card, enter the **show flash: all** command in privileged EXEC mode.

- If geometry and format information does not appear in the output, the card is formatted with a Class B flash file system. Class B files systems are not supported on CF inserted in Cisco 3900 Series, 2900 Series, and 1900 Series Integrated Services Routers.
- If geometry and format information appears in the output, the card is formatted with a Class C flash file system.

The following examples show sample outputs for Class B and Class C flash file systems.

Note Use `flash1:` in the command syntax to access CF in slot1. Use `flash0:` in the command syntax to access CF in slot0.

External Card with Class B Flash File System: Example

The geometry and format information does not appear.

```
Router# show flash: all

Partition   Size    Used      Free      Bank-Size  State          Copy
Mode
  1        125184K  20390K    104793K        0K      Read/Write
Direct

System Compact Flash directory:
File  Length   Name/status
        addr      fcksum  ccksum
  1   6658376  c29xx-i-mz
        0x40      0xE0FF  0xE0FF
  2   14221136  c2900-telcoent-mz
        0x6599C8  0x5C3D  0x5C3D
[20879640 bytes used, 107308776 available, 128188416 total]
125184K bytes of ATA System Compact Flash (Read/Write)

 Chip information NOT available.
```

External Card with Class C Flash File System: Example

The geometry and format information is displayed in this format.

```
Router# show flash: all

-#- --length-- -----date/time------ path
1      6658376 Mar 01 2004 04:27:46 c28xx-i-mz

25268224 bytes available (6664192 bytes used)

******** ATA Flash Card Geometry/Format Info ********

ATA CARD GEOMETRY
   Number of Heads:      4
   Number of Cylinders    490
   Sectors per Cylinder   32
   Sector Size            512
   Total Sectors          62720

ATA CARD FORMAT
   Number of FAT Sectors  31
   Sectors Per Cluster    8
   Number of Clusters     7796
   Number of Data Sectors 62560
   Base Root Sector       155
   Base FAT Sector        93
   Base Data Sector       187
```

Formatting CompactFlash Memory as a Class C File System

Use the **format flash0:** command in privileged EXEC mode to:

- Format CF memory cards with a Class C flash file system
- Remove the files from a CF memory card previously formatted with a Class C flash file system

Note Use **flash1:** in the command syntax to access CF in slot 1. Use **flash0:** in the command syntax to access CF in slot 0.

Formatting CompactFlash Memory as a Class C Flash File System: Example

```
Router# format flash0:
Format operation may take a while. Continue? [confirm]
Format operation will destroy all data in "flash0:".  Continue? [confirm]
Enter volume ID (up to 64 chars)[default flash]:
Current Low End File System flash card in flash will be formatted into DOS
File System flash card!  Continue? [confirm]
Format:Drive communication & 1st Sector Write OK...
Writing Monlib sectors ..............................................................
Monlib write complete
Format:All system sectors written. OK...
Format:Total sectors in formatted partition:250592
Format:Total bytes in formatted partition:128303104
Format:Operation completed successfully.
Format of flash complete
```

File Operations on CompactFlash Memory Cards

This section describes the following file operations for external CF memory cards:

- Copying Files, page B-4
- Displaying Files, page B-5
- Displaying File Content, page B-5
- Displaying Geometry and Format Information, page B-6
- Deleting Files, page B-6
- Renaming Files, page B-6

Copying Files

To copy files, enter the **copy** command in privileged EXEC mode. To indicate a file that is stored in a CF memory card, precede the filename with **flash1: or flash0:.**

Note Use **flash1:** in the command syntax to access CF in slot 1. Use **flash0:** in the command syntax to access CF in slot 0.

Examples: Copying Files

In the following example, the file my-config1 on the CF memory card is copied into the startup-config file in the system memory:

```
Router# copy flash0:my-config1 startup-config

Destination filename [startup-config]?
[OK]
517 bytes copied in 4.188 secs (129 bytes/sec)
```

In the following example, the file my-config2 on the CF memory card is copied into the running-config file in the system memory:

```
Router# copy flash0:my-config2 running-config

Destination filename [running-config]?
709 bytes copied in 0.72 secs
```

Displaying Files

To display a list of files on a CF memory card, enter the **dir flash0:** command in privileged EXEC mode.

Note Use **flash1:** in the command syntax to access CF in slot 1. Use **flash0:** in the command syntax to access CF in slot 0.

```
Router# dir flash0:

Directory of flash0:/
 1580  -rw-     6462268   Mar 06 2004 06:14:02 c2900-universalk9-mz.data
    3  -rw-     6458388   Mar 01 2004 00:01:24 c2900-universalk9-mz.bin
63930368 bytes total (51007488 bytes free)
```

Displaying File Content

To display the content of a file that is stored in flash memory, enter the **more flash0:** command in privileged EXEC mode:

Note Use **flash1:** in the command syntax to access CF in slot 1. Use **flash0:** in the command syntax to access CF in slot 0.

```
Router# more flash0:c29xx-i-mz

00000000: 7F454C46 01020100 00000000 00000000    .ELF .... .... ....
00000010: 00020061 00000001 80008000 00000034    ...a .... .... ...4
00000020: 00000054 20000001 00340020 00010028    ...T  ... .4.  ...(
00000030: 00050008 00000001 0000011C 80008000    .... .... .... ....
00000040: 80008000 00628A44 00650EEC 00000007    .... .b.D .e.l ....
00000050: 0000011C 0000001B 00000001 00000006    .... .... .... ....
00000060: 80008000 0000011C 00004000 00000000    .... .... ..@. ....
00000070: 00000000 00000008 00000000 00000021    .... .... .... ...!
00000080: 00000001 00000002 8000C000 0000411C    .... .... ..@. ..A.
00000090: 00000700 00000000 00000000 00000004    .... .... .... ....
000000A0: 00000000 00000029 00000001 00000003    .... ...) .... ....
000000B0: 8000C700 0000481C 00000380 00000000    ..G. ..H. .... ....
000000C0: 00000000 00000004 00000000 0000002F    .... .... .... .../
000000D0: 00000001 10000003 8000CA80 00004B9C    .... .... ..J. ..K.
000000E0: 00000020 00000000 00000000 00000008    ...  .... .... ....
000000F0: 00000000 0000002F 00000001 10000003    .... .../ .... ....
00000100: 8000CAA0 00004BBC 00623FA4 00000000    ..J  ..K< .b?$ ....
00000110: 00000000 00000008 00000000 3C1C8001    .... .... .... <...
00000120: 679C4A80 3C018001 AC3DC70C 3C018001    g.J. <... ,=G. <...
00000130: AC3FC710 3C018001 AC24C714 3C018001    ,?G. <... ,$G. <...
00000140: AC25C718 3C018001 AC26C71C 3C018001    ,%G. <... ,&G. <...
00000150: AC27C720 3C018001 AC30C724 3C018001    ,'G  <... ,0G$ <...
00000160: AC31C728 3C018001 AC32C72C 3C018001    ,1G( <... ,2G, <...
--More-- q
```

Displaying Geometry and Format Information

To display the geometry and format information of a CF flash file system, enter the **show flash0: filesys** command in privileged EXEC mode.

Note Use **flash1:** in the command syntax to access CF in slot 1. Use **flash0:** in the command syntax to access CF in slot 0.

```
Router# show flash0: filesys

******** ATA Flash Card Geometry/Format Info ********

ATA CARD GEOMETRY
   Number of Heads:      4
   Number of Cylinders    490
   Sectors per Cylinder   32
   Sector Size            512
   Total Sectors          62720

ATA CARD FORMAT
   Number of FAT Sectors  31
   Sectors Per Cluster    8
   Number of Clusters     7796
   Number of Data Sectors 62560
   Base Root Sector       155
   Base FAT Sector        93
   Base Data Sector       187
```

Deleting Files

To delete a file from a CF memory card, enter the **delete flash0:** command.

Note Use **flash1:** in the command syntax to access CF in slot 1. Use **flash0**: in the command syntax to access CF in slot 0.

Note The **dir flash0:** command does not display deleted files and files with errors.

Renaming Files

To rename a file on a CF memory card, enter the **rename** command in privileged EXEC mode.

Note Use **flash1:** in the command syntax to access CF in slot 1. Use **flash0**: in the command syntax to access CF in slot 0.

```
Router# dir flash0:

Directory of flash0:/

    3  -rw-     6458388   Mar 01 2004 00:00:58 c2900-universalk9-mz.tmp
```

```
 1580  -rw-     6462268   Mar 06 2004 06:14:02 c2900-universalk9-mz.3600ata

63930368 bytes total (51007488 bytes free)

Router# rename flash0:c2900-universalk9-mz.tmp flash0:c2900-universalk9-mz

Destination filename [c2900-universalk9-mz]?

Router# dir flash0:

Directory of flash0:/

 1580  -rw-     6462268   Mar 06 2004 06:14:02 c2900-universalk9-mz.3600ata
    3  -rw-     6458388   Mar 01 2004 00:01:24 c2900-universalk9-mz

63930368 bytes total (51007488 bytes free)
```

Directory Operations on a CompactFlash Memory Card

The following sections describe directory operations for external CF memory cards on Cisco routers:

- Entering a Directory and Determining Which Directory You Are In, page B-7
- Creating a New Directory, page B-8
- Removing a Directory, page B-9

Entering a Directory and Determining Which Directory You Are In

To enter a directory of a CF memory card, enter the **cd** command in privileged EXEC mode. The **cd** command specifies or changes the default directory or file system. If you enter **cd** only, without specifying a file system, the router enters the default home directory, which is *flash0*. If you enter **cd flash1:**, the router enters the *flash1* directory.

```
Router# cd
```

To determine which directory you are in, enter the **pwd** command in privileged EXEC mode. The CLI displays which directory or file system is specified as the default by the **cd** command.

```
Router# pwd
```

To display a list of files in the directory that you are in, enter the **dir** command in privileged EXEC mode. The command-line interface will display the files in the file system that was specified as the default by the **cd** command.

```
Router# dir

Directory of flash0:/

 1580  -rw-     6462268   Mar 06 2004 06:14:02 c2900-universalk9-mz.3600ata
    3  -rw-     6458388   Mar 01 2004 00:01:24 c2900-universalk9-mz

63930368 bytes total (51007488 bytes free)
```

Entering a Directory: Example

To enter the /config directory:

```
Router# cd config
```

To verify that you are in the /config directory:

```
Router# pwd

flash0:/config/

Router# dir

Directory of flash0:/config/

  380  -rw-     6462268   Mar 08 2004 06:14:02  myconfig1
  203  -rw-     6458388   Mar 03 2004 00:01:24  myconfig2

63930368 bytes total (51007488 bytes free)
```

Creating a New Directory

To create a directory in flash memory, enter the **mkdir flash0:** command in privileged EXEC mode.

Note Use **flash1:** in the command syntax to access CF in slot 1. Use **flash0**: in the command syntax to access CF in slot 0.

Creating a New Directory: Example

In the following example, a new directory named "config" is created; then a new subdirectory named "test-config" is created within the "config" directory.

```
Router# dir flash0:

Directory of flash0:/

 1580  -rw-     6462268   Mar 06 2004 06:14:02 c2900-universalk9-mz.3600ata
    3  -rw-     6458388   Mar 01 2004 00:01:24 c2900-universalk9-mz

63930368 bytes total (51007488 bytes free)
Router# mkdir flash0:/config

Create directory filename [config]?
Created dir flash0:/config

Router# mkdir flash0:/config/test-config

Create directory filename [/config/test-config]?
Created dir flash0:/config/test-config

Router# dir flash0:

Directory of flash0:/

  3  -rw-     6458208   Mar 01 2004 00:04:08 c2900-universalk9-mz.tmp
 1580  drw-           0   Mar 01 2004 23:48:36  config

128094208 bytes total (121626624 bytes free)
```

Removing a Directory

To remove a directory in flash memory, enter the **rmdir flash0:** command in privileged EXEC mode.

Before you can remove a directory, you must remove all files and subdirectories from the directory.

Note Use **flash1:** in the command syntax to access CF in slot 1. Use **flash0:** in the command syntax to access CF in slot 0.

Example: Removing a Directory

In the following example, the subdirectory test-config is removed.

```
Router# dir

Directory of flash0:/config/

  1581  drw-           0   Mar 01 2004 23:50:08  test-config

128094208 bytes total (121626624 bytes free)
Router# rmdir flash0:/config/test-config

Remove directory filename [/config/test-config]?
Delete flash0:/config/test-config? [confirm]
Removed dir flash0:/config/test-config
Router# dir

Directory of flash0:/config/

No files in directory

128094208 bytes total (121630720 bytes free)
```

Using ROM Monitor

The ROM monitor is accessed during power up or reload when the router does not find a valid system image, the last digit of the boot field in the configuration register is 0, or you enter the Break key sequence during the first 5 seconds after reloading the router.

The following sections describe how to use the ROM monitor in the Cisco 3900 series, 2900 series, 1900 series integrated services routers (ISRs) to manually load a system image or upgrade the system image for disaster, or when there are no TFTP servers or network connections.

- Prerequisites for Using the ROM Monitor, page C-1
- Information About the ROM Monitor, page C-1
- How to Use the ROM Monitor—Typical Tasks, page C-3
- Additional References, page C-27

Prerequisites for Using the ROM Monitor

Connect a terminal or PC to the router console port. For help, see the hardware installation guide for your router.

Information About the ROM Monitor

Before using the ROM monitor, you should understand the following concepts:

- ROM Monitor Mode Command Prompt, page C-1
- Why is the Router in ROM Monitor Mode?, page C-2
- When do I use ROM Monitor?, page C-2
- Tips for Using ROM Monitor Commands, page C-2
- Accessibility, page C-3

ROM Monitor Mode Command Prompt

The ROM monitor uses the `rommon x >` command prompt. The *x* variable begins at 1 and increments each time you press **Return** or **Enter** in ROM monitor mode.

Why is the Router in ROM Monitor Mode?

The router boots to ROM monitor mode when one of the following occurs:

- During power up or reload, the router did not find a valid system image.
- The last digit of the boot field in the configuration register is 0 (for example, 0x100 or 0x0).
- The Break key sequence was entered during the first 60 seconds after reloading the router.

To exit ROM monitor mode, see the "Exiting ROM Monitor Mode" section on page C-25.

When do I use ROM Monitor?

Use ROM monitor in the following situations:

- Manually loading a system image—You can load a system image without configuring the router to load that image in future system reloads or power-cycles. This can be useful for testing a new system image or for troubleshooting. See the "Loading a System Image (boot)" section on page C-8.
- Upgrading the system image when there are no TFTP servers or network connections, and a direct PC connection to the router console is the only viable option—See information about upgrading the system image in the configuration documentation for your router.
- During troubleshooting if the router crashes and hangs—See the "Troubleshooting Crashes and Hangs (stack, context, frame, sysret, meminfo)" section on page C-20.
- Disaster recovery—Use one of the following methods for recovering the system image or configuration file:
  - TFTP download (**tftpdnld**)—Use this method if you can connect a TFTP server directly to the fixed LAN port on your router. See the "Recovering the System Image (tftpdnld)" section on page C-16.

Note Recovering the system image is different from upgrading the system image. You need to recover the system image if it becomes corrupt or if it is deleted because of a disaster that affects the memory device severely enough to require deleting all data on the memory device in order to load a system image.

Tips for Using ROM Monitor Commands

- ROM monitor commands are case sensitive.
- You can halt any ROM monitor command by entering the Break key sequence (**Ctrl-Break**) on the PC or terminal. The Break key sequence varies, depending on the software on your PC or terminal. If **Ctrl-Break** does not work, see the *Standard Break Key Sequence Combinations During Password Recovery* tech note.
- To find out which commands are available on your router and to display command syntax options, see the "Displaying Commands and Command Syntax in ROM Monitor Mode (?, help, -?)" section on page C-7.

Accessibility

This product can be configured using the Cisco command-line interface (CLI). The CLI conforms to accessibility code 508 because it is text based and it relies on a keyboard for navigation. All functions of the router can be configured and monitored through the CLI.

For a complete list of guidelines and Cisco products adherence to accessibility, see the Cisco Accessibility Products document at:

http://www.cisco.com/web/about/responsibility/accessibility/products

How to Use the ROM Monitor—Typical Tasks

This section provides the following procedures:

- Entering ROM Monitor Mode, page C-3
- Displaying Commands and Command Syntax in ROM Monitor Mode (?, help, -?), page C-7
- Displaying Files in a File System (dir), page C-8
- Loading a System Image (boot), page C-8
- Modifying the Configuration Register (confreg), page C-13
- Obtaining Information on USB Flash Devices, page C-14
- Modifying the I/O Memory (iomemset), page C-15
- Recovering the System Image (tftpdnld), page C-16
- Troubleshooting Crashes and Hangs (stack, context, frame, sysret, meminfo), page C-20
- Exiting ROM Monitor Mode, page C-25

Note This section does not describe how to perform all possible ROM monitor tasks. Use the command help to perform any tasks that are not described in this document. See the "Displaying Commands and Command Syntax in ROM Monitor Mode (?, help, -?)" section on page C-7.

Entering ROM Monitor Mode

This section provides two ways to enter ROM monitor mode:

- Using the Break Key Sequence to Interrupt the System Reload and Enter ROM Monitor Mode, page C-4
- Setting the Configuration Register to Boot to ROM Monitor Mode, page C-5

Prerequisites

Connect a terminal or PC to the router console port. For help, see the hardware installation guide for your router.

Using the Break Key Sequence to Interrupt the System Reload and Enter ROM Monitor Mode

To enter ROM monitor mode by reloading the router and entering the Break key sequence, follow these steps.

SUMMARY STEPS

1. **enable**
2. **reload**
3. Press **Ctrl-Break**.

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**reload** **Example:** `Router# reload`	Reloads the operating system.
Step 3	Press **Ctrl-Break**. **Example:** `Router# send break`	Interrupts the router reload and enters ROM monitor mode. • You must perform this step within 60 seconds after you enter the **reload** command. • The Break key sequence varies, depending on the software on your PC or terminal. If **Ctrl-Break** does not work, see the *Standard Break Key Sequence Combinations During Password Recovery* tech note.

Example

Sample Output for the reload Command

```
Use break key sequence to enter rom monitor
Router# reload

Proceed with reload? [confirm]

*Sep 23 15:54:25.871: %SYS-5-RELOAD: Reload requested by console. Reload Reason: Reload
command.
telnet> send break

*** System received an abort due to Break Key ***
signal= 0x3, code= 0x0, context= 0x431aaf40
PC = 0x4008b5dc, Cause = 0x20, Status Reg = 0x3400c102
rommon 1 >
```

Troubleshooting Tips

The Break key sequence varies, depending on the software on your PC or terminal. See the *Standard Break Key Sequence Combinations During Password Recovery* tech note.

What to Do Next

- Proceed to the "Displaying Commands and Command Syntax in ROM Monitor Mode (?, help, -?)" section on page C-7.
- If you use the Break key sequence to enter ROM monitor mode when the router would otherwise have booted the system image, you can exit ROM monitor mode by doing one of the following:
  - Enter the **i** or **reset** command, which restarts the booting process and loads the system image.
  - Enter the **cont** command, which continues the booting process and loads the system image.

Setting the Configuration Register to Boot to ROM Monitor Mode

This section describes how to enter ROM monitor mode by setting the configuration register to boot to ROM monitor mode at the next system reload or power-cycle. For more information about the configuration register, see the *Changing the Configuration Register Settings* document at:

http://www.cisco.com/en/US/docs/routers/access/1800/1841/software/configuration/guide/b_creg.html

Caution Do not set the configuration register by using the **config-register 0x0** command after you have set the baud rate. To set the configuration register without affecting the baud rate, use the current configuration register setting by entering the **show ver | inc configuration** command, and then replacing the last (rightmost) number with a 0 in the configuration register command.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **config-register 0x0**
4. **exit**
5. **write memory**
6. **reload**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**config-register 0x0** **Example:** `Router(config)# config-register 0x0`	Changes the configuration register settings. • The 0x0 setting forces the router to boot to the ROM monitor at the next system reload.
Step 4	**exit** **Example:** `Router(config)# exit`	Exits global configuration mode.
Step 5	**write memory** **Example:** `Router# write memory`	Sets to boot the system image from flash memory.

Step 6	**reload**
	
	Example:
	`Router# reload`
	
	`<output deleted>`
	
	`rommon 1>`
		Reloads the operating system.
		• Because of the 0x0 configuration register setting, the router boots to ROM monitor mode.

Examples

The following example shows how to set the configuration register to boot to ROM monitor mode:

```
Router>
Router> enable
Router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# config-register 0x0
Router(config)# exit
Router#
*Sep 23 16:01:24.351: %SYS-5-CONFIG_I: Configured from console by console
Router# write memory
Building configuration...
[OK]
Router# reload
Proceed with reload? [confirm]
```

```
*Aug 24 11:09:31.167: %SYS-5-RELOAD: Reload requested  by console. Reload Reason: Reload
Command.
System Bootstrap, Version 15.0(1r)M1, RELEASE SOFTWARE (fc1)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 2009 by cisco Systems, Inc.

Total memory size = 2560 MB - On-board = 512 MB, DIMM0 = 2048 MB
C2911 platform with 2621440 Kbytes of main memory
Main memory is configured to 72/72(On-board/DIMM0) bit mode with ECC enabled

Readonly ROMMON initialized
rommon 1 >
```

What to Do Next

Proceed to the "Displaying Commands and Command Syntax in ROM Monitor Mode (?, help, -?)" section on page C-7.

Displaying Commands and Command Syntax in ROM Monitor Mode (?, help, -?)

This section describes how to display ROM monitor commands and command syntax options.

SUMMARY STEPS

1. **?**
   or
   help
2. *command* **-?**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**?**
	or
	help
	
	Example:
	`rommon 1 > ?`
	
	Example:
	`rommon 1 > help`
		Displays a summary of all available ROM monitor commands.

Step 2	*command* **-?** **Example:** `rommon 16 > display -?`	Displays syntax information for a ROM monitor command.

Examples

Sample Output for the help ROM Monitor Command

```
rommon 1 > help

alias               set and display aliases command
boot                boot up an external process
break               set/show/clear the breakpoint
confreg             configuration register utility
cont                continue executing a downloaded image
context             display the context of a loaded image
cookie              display contents of cookie PROM in hex
dev                 list the device table
dir                 list files in file system
frame               print out a selected stack frame
help                monitor builtin command help
history             monitor command history
iomemset            set IO memory percent
meminfo             main memory information
repeat              repeat a monitor command
reset               system reset
rommon-pref         select ROMMON
set                 display the monitor variables
showmon             display currently selected ROM monitor
stack               produce a stack trace
sync                write monitor environment to NVRAM
sysret              print out info from last system return
tftpdnld            tftp image download
unalias             unset an alias
unset               unset a monitor variable
xmodem              x/ymodem image download
hwpart              Read HW resources partition
```

Displaying Files in a File System (dir)

To display a list of the files and directories in the file system, use the **dir** command, as shown in the following example:

```
rommon 1 > dir flash0:
program load complete, entry point: 0x80803000, size: 0x1b340
Directory of flash0:

2      60199000  -rw-     c2900-universalk9-mz.SSA.rel1
14700    1267      -rw-     configuration
rommon 2 > dir usbflash0:
program load complete, entry point: 0x80903000, size: 0x4c400
Directory of usbflash0:

2      54212244  -rw-     c2900-universalk9-mz.SSA
```

Loading a System Image (boot)

This section describes how to load a system image by using the **boot** ROM monitor command.

Prerequisites

Determine the filename and location of the system image that you want to load.

SUMMARY STEPS

1. **boot**
   or
   boot flash0:[*filename*]
   or
   boot *filename tftpserver*
   or
   boot [*filename*]
   or
   boot usbflash0:[*filename*]

DETAILED STEPS

	Command or Action	Purpose

Step 1	**boot**
	or
	boot flash0:[*filename*]
	or
	boot *filename tftpserver* [1]
	or
	boot [*filename*]
	or
	boot usbflash0:[*filename*]
	
	Example:
	`ROMMON > boot`
	
	Example:
	`ROMMON > boot flash0:`
	
	Example:
	`ROMMON > boot someimage 172.16.30.40`
	
	Example:
	`ROMMON > boot someimage`
	
	Example:
	`ROMMON > boot usbflash0:someimage`
		In order, the examples here direct the router to:
		• Boot the first image in flash memory.
		• Boot the first image or a specified image in flash memory.
		Note In IOS, **flash0** will be aliased onto **flash**.
		• Boot the specified image over the network from the specified TFTP server (hostname or IP address).
		• Boot from the boothelper image because it does not recognize the device ID. This form of the command is used to boot a specified image from a network (TFTP) server.
		• Boot the image stored on the USB flash device.
		Note Platforms can boot from USB in ROM monitor with or without a compact flash device. It is not necessary to use a bootloader image from the compact flash device. Partitions, such as usbflash0:2:image_name, are not supported on USB flash drives. The **boot usbflash<x>**: command will boot the first file on the device, if it is a valid image.
		You can override the default boothelper image setting by setting the BOOTLDR Monitor environment variable to point to another image. Any system image can be used for this purpose.
		• Options for the **boot** command are **-x** (load image but do not execute) and **-v** (verbose).

1. Cisco 3925E and Cisco 3945E do not support this boot option.

Examples

The following example shows how to load boot flash memory and USB boot flash memory:

```
rommon 7 > boot flash0:c2900-universalk9-mz.SSA
program load complete, entry point: 0x80803000, size: 0x1b340


IOS Image Load Test
___________________
Digitally Signed Development Software
program load complete, entry point: 0x81000000, size: 0x3968d28
Self decompressing the image :
################################################################################################
################################################################################################
################################################################################################
################################################################################ [OK]

Smart Init is enabled
smart init is sizing iomem
                 TYPE      MEMORY_REQ
          HWIC Slot 0      0x00200000
          HWIC Slot 1      0x00200000
          HWIC Slot 2      0x00200000
          HWIC Slot 3      0x00200000
          PVDM SIMM 0      0x00200000
          PVDM SIMM 1      0x00200000
            SM Slot 1      0x00600000
           ISM Slot 2      0x00600000
    Onboard devices &
         buffer pools      0x0228F000
------------------------------------------------
               TOTAL:      0x03A8F000

Rounded IOMEM up to: 60Mb.
Using 5 percent iomem. [60Mb/1024Mb]

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           170 West Tasman Drive
           San Jose, California 95134-1706


Cisco IOS Software, C2900SM Software (C2900-UNIVERSALK9-M), Experimental Version
12.4(20090709:004325) [ypatel-secport2 128]
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```
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Cisco c2911 (revision 1.0) with 987136K/61440K bytes of memory.
Processor board ID
3 Gigabit Ethernet interfaces
1 terminal line
DRAM configuration is 64 bits wide with parity enabled.
255K bytes of non-volatile configuration memory.
62960K bytes of USB Flash usbflash0 (Read/Write)
248472K bytes of ATA System CompactFlash 0 (Read/Write)
248472K bytes of ATA CompactFlash 1 (Read/Write)

Press RETURN to get started!

*Nov 22 09:20:19.839: %LINK-3-UPDOWN: Interface GigabitEthernet0/0, changed state to up
*Nov 22 09:20:19.839: %LINK-3-UPDOWN: Interface GigabitEthernet0/1, changed state to down
*Nov 22 09:20:19.839: %LINK-3-UPDOWN: Interface GigabitEthernet0/2, changed state to down
*Nov 22 09:20:19.839: %LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet0/0/64, changed state to down
*Nov 22 09:20:19.839: %LINEPROTO-t5-UPDOWN: Line protocol on Interface
GigabitEthernet0/1/64, changed state
Router>
rommon 1 > boot usbflash1:c2900-universalk9-mz.SSA
program load complete, entry point: 0x80803000, size: 0x1b340


IOS Image Load Test
___________________
Digitally Signed Development Software
program load complete, entry point: 0x81000000, size: 0x3968d28
Self decompressing the image :
########################################################################################
########################################################################################
########################################################################################
################################################################################ [OK]

Smart Init is enabled
smart init is sizing iomem
                 TYPE      MEMORY_REQ
          HWIC Slot 0      0x00200000
          HWIC Slot 1      0x00200000
          HWIC Slot 2      0x00200000
          HWIC Slot 3      0x00200000
          PVDM SIMM 0      0x00200000
          PVDM SIMM 1      0x00200000
            SM Slot 1      0x00600000
           ISM Slot 2      0x00600000
    Onboard devices &
         buffer pools      0x0228F000
------------------------------------------------
               TOTAL:      0x03A8F000

Rounded IOMEM up to: 60Mb.
Using 5 percent iomem. [60Mb/1024Mb]

              Restricted Rights Legend
```

```
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           170 West Tasman Drive
           San Jose, California 95134-1706


Cisco IOS Software, C2900SM Software (C2900-UNIVERSALK9-M), Experimental Version
12.4(20090709:004325) [ypatel-secport2 128]
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http://www.cisco.com/wwl/export/crypto/tool/stqrg.html

If you require further assistance please contact us by sending email to
export@cisco.com.

Cisco c2911 (revision 1.0) with 987136K/61440K bytes of memory.
Processor board ID
3 Gigabit Ethernet interfaces
1 terminal line
DRAM configuration is 64 bits wide with parity enabled.
255K bytes of non-volatile configuration memory.
62960K bytes of USB Flash usbflash0 (Read/Write)
248472K bytes of ATA System CompactFlash 0 (Read/Write)
248472K bytes of ATA CompactFlash 1 (Read/Write)

Press RETURN to get started!

*Nov 22 09:20:19.839: %LINK-3-UPDOWN: Interface GigabitEthernet0/0, changed state to up
*Nov 22 09:20:19.839: %LINK-3-UPDOWN: Interface GigabitEthernet0/1, changed state to down
*Nov 22 09:20:19.839: %LINK-3-UPDOWN: Interface GigabitEthernet0/2, changed state to down
*Nov 22 09:20:19.839: %LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet0/0/64, changed state to down
*Nov 22 09:20:19.839: %LINEPROTO-t5-UPDOWN: Line protocol on Interface
GigabitEthernet0/1/64, changed state
Router>
```

What to Do Next

If you want to configure the router to load a specified image at the next system reload or power-cycle, see the following documents:

- Booting Commands" chapter of *Cisco IOS Configuration Fundamentals Command Reference*
- *Cisco IOS Configuration Fundamentals Configuration Guide*

Modifying the Configuration Register (confreg)

This section describes how to modify the configuration register by using the **confreg** ROM monitor command. You can also modify the configuration register setting from the Cisco IOS command-line interface (CLI) by using the **config-register** command in global configuration mode.

Caution Do not set the configuration register by using the **config-register 0x0** command after setting the baud rate. To set the configuration register without affecting the baud rate, use the current configuration register setting by entering the **show ver | inc configuration** command and then replacing the last (rightmost) number with a 0 in the configuration register command.

Restrictions

The modified configuration register value is automatically written into NVRAM, but the new value does not take effect until you reset or power-cycle the router.

SUMMARY STEPS

1. **confreg** [*value*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**confreg** [*value*] **Example:** `rommon > confreg 0x2102`	Changes the configuration register settings while in ROM monitor mode. • Optionally, enter the new hexadecimal value for the configuration register. The value range is from 0x0 to 0xFFFF. • If you do not enter the value, the router prompts for each bit of the 16-bit configuration register.

Examples

In the following example, the configuration register is set to boot the system image from flash memory:

```
rommon 3 > confreg 0x2102
```

In the following example, no value is entered; therefore, the system prompts for each bit in the register:

```
rommon 7 > confreg

Configuration Summary
enabled are:
console baud: 9600
boot: the ROM Monitor
do you wish to change the configuration? y/n [n]: y
enable "diagnostic mode"? y/n [n]: y
enable "use net in IP bcast address"? y/n [n]: y
enable "load rom after netboot fails"? y/n [n]: y
enable "use all zero broadcast"? y/n [n]: y
enable "break/abort has effect"? y/n [n]: y
```

```
enable "ignore system config info"? y/n [n]: y
change console baud rate? y/n [n]: y
enter rate: 0 = 9600, 1 = 4800, 2 = 1200, 3 = 2400 [0]: 0
change the boot characteristics? y/n [n]: y
enter to boot:
0 = ROM Monitor
1 = the boot helper image
2-15 = boot system
[0]: 0
Configuration Summary
enabled are:
diagnostic mode
console baud: 9600
boot: the ROM Monitor
rommon 8>
```

Obtaining Information on USB Flash Devices

This section describes how to obtain information on USB devices that are installed in the router. For instructions on booting from a USB flash device, see the "Loading a System Image (boot)" section on page C-8.

SUMMARY STEPS

1. **dir usbflash** [**x**]:
2. **dev**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**dir usbflash** [**x**]: **Example:** `rommon > dir usbflash0:`	Displays the contents of the USB flash device, including directories, files, permissions, and sizes. • **0**—USB flash device inserted in port 0 • **1**—USB flash device inserted in port 1
Step 2	**dev** **Example:** `ROMMON > dev`	Shows the targeted USB flash devices that are inserted in the router and the valid device names that may or may not be currently inserted.

Examples

Sample Output for the dir usbFlash Command

```
rommon > dir usbflash0:
program load complete, entry point: 0x80903000, size: 0x4c400
Directory of usbflash0:
2 54212244  -rw-     c2900-universalk9-mz
```

```
Sample Output for the dev ROM Monitor Command
rommon 2 > dev
Devices in device table:
```

```
id   name
flash: compact flash
bootflash: boot flash
usbflash0: usbflash0
usbflash1: usbflash1
eprom: eprom
```

Modifying the I/O Memory (iomemset)

This section describes how to modify the I/O memory by using the memory-size **iomemset** command.

Note Use the **iomemset** command only when it is necessary to temporarily set the I/O memory from the ROM monitor mode. Using this command improperly can adversely affect the functioning of the router.

The Cisco IOS software can override the I/O memory percentage if the **memory-size iomem** command is set in the NVRAM configuration. If the Cisco IOS command is present in the NVRAM configuration, the I/O memory percentage set in the ROM monitor with the **iomemset** command is used only the first time the router is booted up. Subsequent reloads use the I/O memory percentage set by using the **memory-size iomem** command that is saved in the NVRAM configuration.

If you need to set the router I/O memory permanently by using a manual method, use the **memory-size iomem** Cisco IOS command. If you set the I/O memory from the Cisco IOS software, you must restart the router for I/O memory to be set properly.

When the configured I/O memory exceeds the IOS limit (1G), IOS will automatically set an appropriate I/O memory size and print this message: *IOMEM size calculated is greater than maximum allowed during boot up.*

SUMMARY STEPS

1. **iomemset** *i/o-memory percentage*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**iomemset** *i/o-memory percentage* **Example:** `rommon> iomemset 15`	Reallocates the percentage of DRAM used for I/O memory and processor memory.

Examples

In the following example, the percentage of DRAM used for I/O memory is set to 15:

```
rommon 2 > iomemset
usage: iomemset [smartinit | 5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 ]
rommon 3 >
rommon 3 > iomemset 15

Invoking this command will change the io memory percent
*****WARNING:IOS may not keep this value*****
Do you wish to continue? y/n: [n]: y

rommon 4 > meminfo
-------------------------------------------------
Current Memory configuration is:
Onboard SDRAM: Size = 128 MB : Start Addr = 0x10000000
-----Bank 0 128 MB
-----Bank 1   0 MB
Dimm 0: Size = 256 MB : Start Addr = 0x00000000
-----Bank 0 128 MB
-----Bank 1 128 MB
-------------------------------------------------
Main memory size: 384 MB in 64 bit mode.
Available main memory starts at 0xa0015000, size 393132KB
IO (packet) memory size: 10 percent of main memory.
NVRAM size: 191KB
```

Recovering the System Image (tftpdnld)

This section describes how to download a Cisco IOS software image from a remote TFTP server to the router flash memory by using the **tftpdnld** command in ROM monitor mode.

Caution Use the **tftpdnld** command only for disaster recovery because it can erase all existing data in flash memory before it downloads a new software image to the router.

Before you can enter the **tftpdnld** command, you must set the ROM monitor environment variables.

Prerequisites

Connect the TFTP server to a fixed network port on your router.

Restrictions

- LAN ports on network modules or interface cards are not active in ROM monitor mode. Therefore, only a fixed port on your router can be used for TFTP download. This can be a fixed Ethernet port on the router, that is either of the two Gigabit Ethernet ports on Cisco routers with those ports.
- You can only download files to the router. You cannot use the **tftpdnld** command to retrieve files from the router.

SUMMARY STEPS

1. **IP_ADDRESS=***ip_address*
2. **IP_SUBNET_MASK=***ip_address*
3. **DEFAULT_GATEWAY=***ip_address*
4. **TFTP_SERVER=***ip_address*
5. **TFTP_FILE=**[*directory-path*/]*filename*
6. **GE_PORT=**[**0** | **1** | **2**]
7. **GE_SPEED_MODE=**[**0** | **1** | **2** | **3** | **4** | **5**]
8. **TFTP_MEDIA_TYPE=**[**0** | **1**]
9. **TFTP_CHECKSUM=**[**0** | **1**]
10. **TFTP_DESTINATION=[flash0**: | **flash1:** | **usbflash0:** | **usbflash1:**]
11. **TFTP_MACADDR=***MAC_address*
12. **TFTP_RETRY_COUNT=***retry_times*
13. **TFTP_TIMEOUT=***time*
14. **TFTP_VERBOSE=***setting*
15. **set**
16. **tftpdnld** [**-h**] [**-r**]
17. **y**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**IP_ADDRESS=***ip_address* **Example:** `rommon > IP_ADDRESS=172.16.23.32`	Sets the IP address of the router.
Step 2	**IP_SUBNET_MASK=***ip_address* **Example:** `rommon > IP_SUBNET_MASK=255.255.255.224`	Sets the subnet mask of the router.
Step 3	**DEFAULT_GATEWAY=***ip_address* **Example:** `rommon > DEFAULT_GATEWAY=172.16.23.40`	Sets the default gateway of the router.
Step 4	**TFTP_SERVER=***ip_address* **Example:** `rommon > TFTP_SERVER=172.16.23.33`	Sets the TFTP server from which the software is downloaded.

	Command or Action	Purpose
Step 5	**TFTP_FILE=**[*directory-path*/]*filename* **Example:** `rommon > TFTP_FILE=archive/rel22/c2801-i-mz`	Sets the name and location of the file that is downloaded to the router.
Step 6	**GE_PORT=**[**0** | **1** | **2**] **Example:** `rommon > GE_PORT=0`	(Optional) Sets the input port to use one of the Gigabit Ethernet ports. The default is 0.
Step 7	**GE_SPEED_MODE=**[**0** | **1** | **2** | **3** | **4** | **5**] **Example:** `rommon > GE_SPEED_MODE=3`	(Optional) Sets the Gigabit Ethernet port speed mode, with these options: • **0**—10 Mbps, half-duplex • **1**—10 Mbps, full-duplex • **2**—100 Mbps, half-duplex • **3**—100 Mbps, full-duplex • **4**—1 Gbps, full-duplex • **5**—Automatic selection (default)
Step 8	**TFTP_MEDIA_TYPE=**[**0** | **1**] **Example:** `rommon > MEDIA_TYPE=1`	(Optional) Sets the Gigabit Ethernet connection media type, RJ-45 (0) or SFP (1). Small form-factor pluggable (SFP) mode is applicable only if GE_PORT=0 (gig 0/0); RJ-45 mode is available on both gig 0/0 and gig 0/1 (GE_PORT = 0 or 1). The default is 0.
Step 9	**TFTP_CHECKSUM=[0 | 1]** **Example:** `rommon > TFTP_CHECKSUM=0`	(Optional) Determines whether the router performs a checksum test on the downloaded image. • **1**—Checksum test is performed (default). • **0**—No checksum test is performed.
Step 10	**TFTP_DESTINATION=[flash0: | flash1**: | **usbflash0: | usbflash1:]** **Example:** `rommon > TFTP_DESTINATION=usbflash0:`	(Optional) Designates the targeted flash device as compact flash or USB flash. • **flash0:**—Compact flash device in port 0(default) • **flash1:**—Compact flash device in port 1 • **usbflash0:**—USB flash device inserted in port 0 • **usbflash1:**—USB flash device inserted in port 1
Step 11	**TFTP_MACADDR=***MAC_address* **Example:** `rommon > TFTP_MACADDR=000e.8335.f360`	(Optional) Sets the Media Access Controller (MAC) address for this router.
Step 12	**TFTP_RETRY_COUNT=***retry_times* **Example:** `rommon > TFTP_RETRY_COUNT=10`	(Optional) Sets the number of times that the router attempts Address Resolution Protocol (ARP) and TFTP download. The default is 18.

	Command or Action	Purpose
Step 13	**TFTP_TIMEOUT=***time* **Example:** `TFTP_TIMEOUT=1800`	(Optional) Sets the amount of time, in seconds, before the download process times out. The default is 7200 seconds (120 minutes).
Step 14	**TFTP_ACK_RETRY=***time* **Example:** `TFTP_TIMEOUT=6`	(Optional) Sets the amount of time, in seconds, before the client will resend the ACK packet to indicate to the server to continue transmission of the remaining packets. The default is 5 seconds.

Step 15	**TFTP_VERBOSE=***setting*
	
	Example:
	`rommon > TFTP_VERBOSE=2`
		(Optional) Configures how the router displays file download progress, with these options:
		• **0**—No progress is displayed.
		• **1**—Exclamation points (!!!) are displayed to indicate file download progress. This is the default setting.
		• **2**—Detailed progress is displayed during the file download process; for example:
		`Initializing interface.`
		`Interface link state up.`
		`ARPing for 1.4.0.1`
		`ARP reply for 1.4.0.1 received.`
		`MAC address 00:00:0c:07:ac:01`

Step 16	**set** **Example:** `rommon > set`	Displays the ROM monitor environment variables. Verify that you correctly configured the ROM monitor environment variables.
Step 17	**tftpdnld** [**-h**] [**-r**] **Example:** `rommon > tftpdnld`	Downloads the system image specified by the ROM monitor environment variables. • Entering **-h** displays command syntax help text. • Entering **-r** downloads and boots the new software but does not save the software to flash memory. • Using no option (that is, using neither **-h** nor **-r**) downloads the specified image and saves it in flash memory.
Step 18	**y** **Example:** `Do you wish to continue? y/n:  [n]:  y`	Confirms that you want to continue with the TFTP download.

Examples

Sample Output for Recovering the System Image (tftpdnld)

```
rommon 16 > IP_ADDRESS=171.68.171.0
rommon 17 > IP_SUBNET_MASK=255.255.254.0
rommon 18 > DEFAULT_GATEWAY=171.68.170.3
rommon 19 > TFTP_SERVER=171.69.1.129
rommon 20 > TFTP_FILE=c2801-is-mz.113-2.0.3.Q
rommon 21 > tftpdnld

              IP_ADDRESS: 171.68.171.0
          IP_SUBNET_MASK: 255.255.254.0
         DEFAULT_GATEWAY: 171.68.170.3
             TFTP_SERVER: 171.69.1.129
               TFTP_FILE: c2801-is-mz.113-2.0.3.Q

     Invoke this command for disaster recovery only.
     WARNING: all existing data in all partitions on flash will be lost!
     Do you wish to continue? y/n:  [n]:  y

     Receiving c2801-is-mz.113-2.0.3.Q from 171.69.1.129 !!!!!.!!!!!!!!!!!!!!!!!!!!.!!
     File reception completed.
     Copying file c2801-is-mz.113-2.0.3.Q to flash.
     Erasing flash at 0x607c0000
     program flash location 0x60440000
     rommon 22 >
```

Sample Output for the set ROM Monitor Command

```
rommon 3 > set

    PS1=rommon ! >
    IP_ADDRESS=172.18.16.76
    IP_SUBNET_MASK=255.255.255.192
    DEFAULT_GATEWAY=172.18.16.65
    TFTP_SERVER=172.18.16.2
    TFTP_FILE=anyname/rel22_Jan_16/c2801-i-mz
```

What to Do Next

If you want to configure the router to load a specified image at the next system reload or power-cycle, see the "Loading and Managing System Images" section in *Cisco IOS Configuration Fundamentals Command Reference.*

Troubleshooting Crashes and Hangs (stack, context, frame, sysret, meminfo)

This section lists and describes some ROM monitor commands that can be used to troubleshoot router crashes and hangs.

Most ROM monitor **debug** commands are functional only when the router crashes or hangs. If you enter a **debug** command when crash information is not available, the following error message appears:

```
"xxx: kernel context state is invalid, can not proceed."
```

The ROM monitor commands in this section are all optional and can be entered in any order.

Router Crashes

A router or system *crash* is a situation in which the system detects an unrecoverable error and restarts itself. The errors that cause crashes are typically detected by processor hardware, which automatically branches to special error-handling code in the ROM monitor. The ROM monitor identifies the error, prints a message, saves information about the failure, and restarts the system. For detailed information about troubleshooting crashes, see the *Troubleshooting Router Crashes* and *Understanding Software-forced Crashes* tech notes.

Router Hangs

A router or system *hang* is a situation in which the system does not respond to input at the console port or to queries sent from the network, such as Telnet and Simple Network Management Protocol (SNMP).

Router hangs occur when:

- The console does not respond
- Traffic does not pass through the router

Router hangs are discussed in detail in the *Troubleshooting Router Hangs* tech note.

ROM Monitor Console Communication Failure

Under certain mis-configuration situations, it can be impossible to establish a console connection with the router due to a speed mismatch or other incompatibility. The most obvious symptom is erroneous characters in the console display.

If a ROM monitor failure of this type occurs, you may need to change a jumper setting on the motherboard so that the router can boot for troubleshooting. Procedures for accessing the motherboard and jumper locations are described in the installation of internal components section of the hardware installation document for your router.

The jumper to be changed is DUART DFLT, which sets the console connection data rate to 9600 regardless of user configuration. The jumper forces the data rate to a known good value.

Restrictions

Do not manually reload or power-cycle the router unless reloading or power cycling is required for troubleshooting a router crash. The system reload or power-cycle can cause important information to be lost that is needed for determining the root cause of the problem.

SUMMARY STEPS

1. **stack**
   or
   k
2. **context**
3. **frame** [*number*]
4. **sysret**
5. **meminfo**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**stack** or **k** **Example:** `rommon > stack`	(Optional) Obtains a stack trace. • For detailed information on how to effectively use this command in ROM monitor mode, see the *Troubleshooting Router Hangs* tech note.
Step 2	**context** **Example:** `rommon > context`	(Optional) Displays the CPU context at the time of the fault. • If it is available, the context from kernel mode and process mode of a loaded image is displayed.
Step 3	**frame** [*number*] **Example:** `rommon > frame 4`	(Optional) Displays an entire individual stack frame. • The default is 0 (zero), which is the most recent frame.
Step 4	**sysret** **Example:** `rommon > sysret`	(Optional) Displays return information from the last booted system image. • The return information includes the reason for terminating the image, a stack dump of up to eight frames, and, if an exception is involved, the address at which the exception occurred.
Step 5	**meminfo** [-l] **Example:** `rommon > meminfo`	(Optional) Displays memory information, including: • Main memory size, starting address, and available range • Packet memory size • NVRAM size Alternatively, using the **meminfo -l** command provides information on supported DRAM configurations for the router.

Examples

This section provides the following examples:

- Sample Output for the stack ROM Monitor Command, page C-23
- Sample Output for the context ROM Monitor Command, page C-23
- Sample Output for the frame ROM Monitor Command, page C-24
- Sample Output for the sysret ROM Monitor Command, page C-24
- Sample Output for the meminfo ROM Monitor Command, page C-24

Sample Output for the stack ROM Monitor Command

```
rommon 6> stack

Kernel Level Stack Trace:
Initial SP = 0x642190b8, Initial PC = 0x607a0d44, RA = 0x61d839f8
Frame 0 : FP= 0x642190b8, PC= 0x607a0d44,   0 bytes
Frame 1 : FP= 0x642190b8, PC= 0x61d839f8,  24 bytes
Frame 2 : FP= 0x642190d0, PC= 0x6079b6c4,  40 bytes
Frame 3 : FP= 0x642190f8, PC= 0x6079ff70,  32 bytes
Frame 4 : FP= 0x64219118, PC= 0x6079eaec,   0 bytes

Process Level Stack Trace:
Initial SP = 0x64049cb0, Initial PC = 0x60e3b7f4, RA = 0x60e36fa8
Frame 0 : FP= 0x64049cb0, PC= 0x60e3b7f4,  24 bytes
Frame 1 : FP= 0x64049cc8, PC= 0x60e36fa8,  24 bytes
Frame 2 : FP= 0x64049ce0, PC= 0x607a5800, 432 bytes
Frame 3 : FP= 0x64049e90, PC= 0x607a8988,  56 bytes
Frame 4 : FP= 0x64049ec8, PC= 0x64049f14,   0 bytes
```

Sample Output for the context ROM Monitor Command

```
rommon 7> context

Kernel Level Context:
 Reg       MSW        LSW      | Reg       MSW        LSW
------  ---------- ---------- | -----   ---------- ----------
zero   : 00000000   00000000   | s0     : 00000000   34018001
AT     : 00000000   24100000   | s1     : 00000000   00000001
v0     : 00000000   00000003   | s2     : 00000000   00000003
v1     : 00000000   00000000   | s3     : 00000000   00000000
a0     : 00000000   0000002b   | s4     : 00000000   64219118
a1     : 00000000   00000003   | s5     : 00000000   62ad0000
a2     : 00000000   00000000   | s6     : 00000000   63e10000
a3     : 00000000   64219118   | s7     : 00000000   63e10000
t0     : 00000000   00070808   | t8     : ffffffff   e7400884
t1     : 00000000   00000000   | t9     : 00000000   00000000
t2     : 00000000   63e10000   | k0     : 00000000   00000000
t3     : 00000000   34018001   | k1     : 00000000   63ab871c
t4     : ffffffff   ffff80fd   | gp     : 00000000   63c1c2d8
t5     : ffffffff   fffffffe   | sp     : 00000000   642190b8
t6     : 00000000   3401ff02   | s8     : 00000000   6429274c
t7     : 00000000   6408d464   | ra     : 00000000   61d839f8
HI     : ffffffff   e57fce22   | LO     : ffffffff   ea545255
EPC    : 00000000   607a0d44   | ErrPC  : ffffffff   bfc05f2c
Stat   : 34018002              | Cause  : 00000020

Process Level Context:
 Reg       MSW        LSW      | Reg       MSW        LSW
------  ---------- ---------- | -----   ---------- ----------
zero   : 00000000   00000000   | s0     : 00000000   6401a6f4
AT     : 00000000   63e10000   | s1     : 00000000   00000000
v0     : 00000000   00000000   | s2     : 00000000   64049cf0
v1     : 00000000   00000440   | s3     : 00000000   63360000
a0     : 00000000   00000000   | s4     : 00000000   63360000
a1     : 00000000   00070804   | s5     : 00000000   62ad0000
a2     : 00000000   00000000   | s6     : 00000000   63e10000
a3     : 00000000   00000000   | s7     : 00000000   63e10000
t0     : 00000000   00000000   | t8     : ffffffff   e7400884
t1     : 00000000   64928378   | t9     : 00000000   00000000
t2     : 00000000   00000001   | k0     : 00000000   644822e8
t3     : ffffffff   ffff00ff   | k1     : 00000000   61d86d84
t4     : 00000000   6079eee0   | gp     : 00000000   63c1c2d8
```

```
t5     : 00000000   00000001  | sp     : 00000000   64049cb0
t6     : 00000000   00000000  | s8     : 00000000   6429274c
t7     : 00000000   6408d464  | ra     : 00000000   60e36fa8
HI     : ffffffff   e57fce22  | LO     : ffffffff   ea545255
EPC    : 00000000   60e3b7f4  | ErrPC  : ffffffff   ffffffff
Stat   : 3401ff03             | Cause  : ffffffff
```

Sample Output for the frame ROM Monitor Command

```
rommon 6 > frame 2

Stack Frame 2, SP = 0x642190d0, Size = 40 bytes
[0x642190d0 : sp + 0x000] = 0xffffffff
[0x642190d4 : sp + 0x004] = 0xbfc05f2c
[0x642190d8 : sp + 0x008] = 0xffffffff
[0x642190dc : sp + 0x00c] = 0xffffffff
[0x642190e0 : sp + 0x010] = 0x6401a6f4
[0x642190e4 : sp + 0x014] = 0x00000000
[0x642190e8 : sp + 0x018] = 0x64049cf0
[0x642190ec : sp + 0x01c] = 0x63360000
[0x642190f0 : sp + 0x020] = 0x63360000
[0x642190f4 : sp + 0x024] = 0x6079ff70
```

Sample Output for the sysret ROM Monitor Command

```
rommon 8> sysret

System Return Info:
count: 19,  reason: user break
pc:0x801111b0,  error address: 0x801111b0
Stack Trace:
FP: 0x80005ea8, PC: 0x801111b0
FP: 0x80005eb4, PC: 0x80113694
FP: 0x80005f74, PC: 0x8010eb44
FP: 0x80005f9c, PC: 0x80008118
FP: 0x80005fac, PC: 0x80008064
FP: 0x80005fc4, PC: 0xfff03d70
FP: 0x80005ffc, PC: 0x00000000
FP: 0x00000000, PC: 0x00000000
```

Sample Output for the meminfo ROM Monitor Command

```
rommon 3> meminfo

-------------------------------------------------
Current Memory configuration is:
Onboard SDRAM: Size = 128 MB : Start Addr = 0x10000000
-----Bank 0 128 MB
-----Bank 1   0 MB
Dimm 0: Size = 256 MB : Start Addr = 0x00000000
-----Bank 0 128 MB
-----Bank 1 128 MB
-------------------------------------------------
Main memory size: 384 MB in 64 bit mode.
Available main memory starts at 0xa0015000, size 393132KB
IO (packet) memory size: 10 percent of main memory.
NVRAM size: 191KB
```

You can also use the **meminfo -l** command to show the supported DRAM configurations for the router. The following is sample output for the command:

```
rommon 4 > meminfo -l

The following 64 bit memory configs are supported:
-------------------------------------------------
Onboard SDRAM           DIMM SOCKET 0           TOTAL MEMORY
Bank 0  Bank1           Bank 0 Bank 1
-------------           -------------           ------------
128 MB   0 MB             0 MB   0 MB           128 MB
128 MB   0 MB            64 MB   0 MB           192 MB
128 MB   0 MB            64 MB  64 MB           256 MB
128 MB   0 MB           128 MB   0 MB           256 MB
128 MB   0 MB           128 MB 128 MB           384 MB
128 MB   0 MB           256 MB   0 MB           384 MB
```

Troubleshooting Tips

See the following tech notes:

- *Troubleshooting Router Crashes*
- *Understanding Software-forced Crashes*
- *Troubleshooting Router Hangs*

Exiting ROM Monitor Mode

This section describes how to exit ROM monitor mode and enter the Cisco IOS command-line interface (CLI). The method that you use to exit ROM monitor mode depends on how your router entered ROM monitor mode:

- If you reload the router and enter the Break key sequence to enter ROM monitor mode when the router would otherwise have booted the system image, you can exit ROM monitor mode by doing either of the following:
  - Enter the **i** command or the **reset** command, which restarts the booting process and loads the system image.
  - Enter the **cont** command, which continues the booting process and loads the system image.
- If your router entered ROM monitor mode because it could not locate and load the system image, perform the steps in the following procedure.

SUMMARY STEPS

1. **dir flash0:**[*directory*]
2. **boot flash0:**[*directory*] [*filename*]
   or
   boot *filename tftpserver*
   or
   boot [*filename*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**dir flash0:**[*directory*] **Example:** `rommon > dir flash0:`	Displays a list of the files and directories in flash memory. • Locate the system image that you want the router to load. • If the system image is not in flash memory, use the second or third option in Step 2.

Step 2	**boot flash0:**[*directory*] [*filename*]
	or
	boot *filename tftpserver*
	or
	boot [*filename*]
	
	Example:
	`ROMMON > boot flash0:myimage`
	
	Example:
	`ROMMON > boot someimage 172.16.30.40`
	
	Example:
	`ROMMON > boot`
		In order, the examples here direct the router to:
		• Boot the first image or a specified image in flash memory.
		• Boot the specified image over the network from the specified TFTP server (hostname or IP address).
		• Boot from the boothelper image because it does not recognize the device ID. This form of the command is used to netboot a specified image.
		You can override the default boothelper image setting by setting the BOOTLDR Monitor environment variable to point to another image. Any system image can be used for this purpose.
		Note Options to the boot command are **-x** (load image but do not execute) and **-v** (verbose).

Examples

Sample Output for the dir flash: Command in ROM Monitor mode

```
rommon > dir flash0:

          File size               Checksum   File name
       2229799 bytes (0x220627)    0x469e    c2801-j-m2.113-4T
```

What to Do Next

If you want to configure the router to load a specified image at the next system reload or power-cycle, see the "Loading and Managing System Images" section in *Cisco IOS Configuration Fundamentals Command Reference.*

Additional References

The following sections provide references related to using the ROM monitor.

Related Documents

Related Topic	Document Title
Connecting your PC to the router console port	Hardware installation guide for your router
Break key sequence combinations for entering ROM monitor mode within the first 60 seconds of rebooting the router	*Standard Break Key Sequence Combinations During Password Recovery*
Upgrading the ROM monitor	*ROM Monitor Download Procedures for Cisco 2691, Cisco, 3631, Cisco 3725, and Cisco 3745 Routers*
Using the boot image (Rx-boot) to recover or upgrade the system image	*How to Upgrade from ROMmon Using the Boot Image*
Booting and configuration register commands	*Cisco IOS Configuration Fundamentals Command Reference*
Loading and maintaining system images; rebooting	*Cisco IOS Configuration Fundamentals Configuration Guide*
Choosing and downloading system images	Software Center at http://www.cisco.com/kobayashi/sw-center/index.shtml
Router crashes	*Troubleshooting Router Crashes* *Understanding Software-forced Crashes*
Router hangs	*Troubleshooting Router Hangs*

Technical Assistance

Description	Link
Technical Assistance Center (TAC) home page, containing 30,000 pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.[1]	http://www.cisco.com/public/support/tac/home.shtml

1. You must have an account at Cisco.com. If you do not have an account or have forgotten your username or password, click **Cancel** at the login dialog box and follow the instructions that appear.

Changing the Configuration Register Settings

The following sections describe the 16-bit configuration register in NVRAM in the Cisco 3900 series, Cisco 2900 series, and Cisco 1900 series integrated services routers (ISRs):

- About the Configuration Register, page D-1
- Changing the Configuration Register Settings, page D-4
- Displaying the Configuration Register Settings, page D-5
- Configuring the Console Line Speed (Cisco IOS CLI), page D-5

About the Configuration Register

The router has a 16-bit configuration register in NVRAM. Each bit has value 1 (on or set) or value 0 (off or clear), and each bit setting affects the router behavior upon the next reload power cycle.

You can use the configuration register to

- Force the router to boot into the ROM monitor (bootstrap program)
- Select a boot source and default boot filename
- Enable or disable the Break function
- Control broadcast addresses
- Recover a lost password
- Change the console line speed

Table D-1 describes the configuration register bits.

Table D-1 Configuration Register Bit Descriptions

Bit Number	Hexadecimal	Meaning
00–03	0x0000–0x000F	Boot field. The boot field setting determines whether the router loads an operating system and where it obtains the system image. See Table D-2 for details.
06	0x0040	Causes the system software to ignore the contents of NVRAM.
07	0x0080	OEM[1] bit enabled.

Table D-1 Configuration Register Bit Descriptions (continued)

Bit Number	Hexadecimal	Meaning
08	0x0100	Controls the console Break key: • (Factory default) Setting bit 8 causes the processor to ignore the console Break key. • Clearing bit 8 causes the processor to interpret Break as a command to force the router into the ROM monitor mode, halting normal operation. Break can always be sent in the first 60 seconds while the router is rebooting, regardless of the configuration register settings.
09	0x0200	This bit controls the system boot: • Setting bit 9 causes the system to use the secondary bootstrap. • (Factory default) Clearing bit 9 causes the system to boot from flash memory. • This bit is typically not modified.
10	0x0400	Controls the host portion of the IP broadcast address: • Setting bit 10 causes the processor to use all zeros. • (Factory default) Clearing bit 10 causes the processor to use all ones. Bit 10 interacts with bit 14, which controls the network and subnet portions of the IP broadcast address. See Table D-3 for the combined effects of bits 10 and 14.
05, 11, 12	0x0020, 0x0800, 0x1000	Controls the console line speed. See Table D-4 for the eight available bit combinations and console line speeds. Factory default is 9600 baud, where bits 5, 11, and 12 are all zero (clear). **Note** You cannot change the console line speed configuration register bits from the Cisco IOS CLI[2]. You can, however, change these bits from the ROM monitor. Or, instead of changing the configuration register settings, you can set the console line speed through other Cisco IOS commands.
13	0x2000	Determines how the router responds to a network boot failure: • Setting bit 13 causes the router to boot the default ROM software after 6 unsuccessful network boot attempts. • (Factory default) Clearing bit 13 causes the router to indefinitely continue network boot attempts.
14	0x4000	Controls the network and subnet portions of the IP broadcast address: • Setting bit 10 causes the processor to use all zeros. • (Factory default) Clearing bit 10 causes the processor to use all ones. Bit 14 interacts with bit 10, which controls the host portion of the IP broadcast address. See Table D-3 for the combined effect of bits 10 and 14.
15	0x8000	Enables diagnostic messages and ignores the contents of NVRAM.

1. OEM = Original Equipment Manufacturer
2. CLI = command-line interface

Table D-2 describes the boot field, which is the lowest four bits of the configuration register (bits 3, 2, 1, and 0). The boot field setting determines whether the router loads an operating system and where the router obtains the system image.

Table D-2 Boot Field Configuration Register Bit Descriptions

Boot Field (Bits 3, 2, 1, and 0)	Meaning
0000 (0x0)	At the next power cycle or reload, the router boots to the ROM monitor (bootstrap program). To use the ROM monitor, you must use a terminal or PC that is connected to the router console port. For information about connecting the router to a PC or terminal, see the hardware installation guide for your router. In ROM monitor mode, you must manually boot the system image or any other image by using the **boot** ROM monitor command.
0001 (0x01)	Boots the first image in flash memory as a system image.
0010 - 1111 (0x02 - 0xF)	At the next power cycle or reload, the router sequentially processes each **boot system** command in global configuration mode that is stored in the configuration file until the system boots successfully. If no **boot system** commands are stored in the configuration file, or if executing those commands is unsuccessful, then the router attempts to boot the first image file in flash memory.

Table D-3 shows how each setting combination of bits 10 and 14 affects the IP broadcast address.

Table D-3 Broadcast Address Configuration Register Bit Combinations

Bit 10	Bit 14	Broadcast Address (<net> <host>)
0	0	<ones> <ones>
1	0	<ones> <zeros>
1	1	<zeros> <zeros>
0	1	<zeros> <ones>

Table D-4 shows the console line speed for each setting combination of bits 5, 11, and 12.

Table D-4 Console Line Speed Configuration Register Bit Combinations

Bit 5	Bit 11	Bit 12	Console Line Speed (baud)
1	1	1	115200
1	0	1	57600
1	1	0	38400
1	0	0	19200
0	0	0	9600
0	1	0	4800

Table D-4 Console Line Speed Configuration Register Bit Combinations (continued)

Bit 5	Bit 11	Bit 12	Console Line Speed (baud)
0	1	1	2400
0	0	1	1200

Changing the Configuration Register Settings

You can change the configuration register settings from either the ROM monitor or the Cisco IOS CLI. This section describes how to modify the configuration register settings from the Cisco IOS CLI.

To change the configuration register using the ROM monitor, see Appendix C, "Using ROM Monitor," in this guide.

To change the configuration register settings from the Cisco IOS CLI, complete the following steps:

Step 1 Connect a terminal or PC to the router console port. If you need help, see the hardware installation guide for your router.

Step 2 Configure your terminal or terminal emulation software for 9600 baud (default), 8 data bits, no parity, and 2 stop bits.

Step 3 Power on the router.

Step 4 If you are asked whether you would like to enter the initial dialog, answer **no**:

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

After a few seconds, the user EXEC prompt (`Router>`) appears.

Step 5 Enter privileged EXEC mode by typing **enable** and, if prompted, enter your password:

```
Router> enable
Password: password
Router#
```

Step 6 Enter global configuration mode:

```
Router# configure terminal

Enter configuration commands, one per line.
Edit with DELETE, CTRL/W, and CTRL/U; end with CTRL/Z
```

Step 7 To change the configuration register settings, enter the **config-register** *value* command, where *value* is a hexadecimal number preceded by **0x**:

```
Router(config)# config-register 0xvalue
```

Note The Cisco IOS software does not allow you to change the console speed bits directly with the **config-register** command. To change the console speed from the Cisco IOS CLI, see the "Configuring the Console Line Speed (Cisco IOS CLI)" section on page D-5.

Step 8 Exit global configuration mode:

```
Router(config)# end
Router#
```

Step 9 Save the configuration changes to NVRAM:

```
Router# copy run start
```

The new configuration register settings are saved to NVRAM, but they do not take effect until the next router reload or power cycle.

Displaying the Configuration Register Settings

To display the configuration register settings that are currently in effect and the settings that will be used at the next router reload, enter the **show version** command in privileged EXEC mode.

The configuration register settings are displayed in the last line of the **show version** command output:

```
Configuration register is 0x142 (will be 0x142 at next reload)
```

Configuring the Console Line Speed (Cisco IOS CLI)

The combined setting of bits 5, 11, and 12 determines the console line speed. You can modify these particular configuration register bits only from the ROM monitor.

To change the configuration register using the ROM monitor, see Appendix C, "Using ROM Monitor".

To configure the console line speed from the Cisco IOS command-line interface, complete the following steps.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line console 0**
4. **speed baud**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**enable**
	
	Example:
	`Router> enable`
	`Password: password`
	`Router#`
		Enables privileged EXEC mode. Enter your password if prompted.

Step 2	**configure terminal**
	
	Example:
	`Router# configure terminal`
	`Router(config)#`
		Enters global configuration mode.

	Command or Action	Purpose

Step 3	**line console 0**
	
	Example:
	`Router(config)# line console 0`
	`Router(config-line)#`
		Specifies the console line and enters line configuration mode.

Step 4	**speed baud** **Example:** `Router(config-line)# speed baud`	Specifies the console line speed. Possible values (in baud): 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200.