Cisco 900 Series Integrated Services Routers Software Configuration Guide

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Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
http://www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883

Cisco 900 Series, Integrated Services Routers Software Configuration Guide

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

This guide provides information about how to configure the various features of Cisco 900 Series integrated services routers (ISRs).

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 document is organized into the following chapters:

Chapter	Description
Product Overview	Provides an overview of the hardware and software features of Cisco 900 Series ISRs.
Installing the Software	Describes how to upgrade Cisco IOS image, Field Replaceable units, and use Cisco Licenses.
Basic Router Configuration	Describes how to perform the basic router configuration, interface configuration, and routing configuration.

Chapter	Description
Configuring Ethernet Switches	Describes the procedures for configuring Gigabit Ethernet (GE) switch.
Configuring PPP over Ethernet with NAT	Describes the procedures for configuring Point-to-Point Protocol over Ethernet (PPPoE) clients and network address translation (NAT).
Configuring a LAN with DHCP and VLANs	Describes the procedures for configuring LAN with DHCP and VLANs.
Configuring Identity Features on Layer 3 Interface	Describes configuring the identify features on Layer 3 interfaces.
Configuring Security Features	Describes how to configure security features.
Configuring VDSL2 and ADSL2/2+	Describes how to configure multimode VDSL2 and ADSl2+ WAN connectivity on a Cisco 900 series ISR.
Configuring 4G Wireless WAN	Describes how to configure the 4G Wireless WAN interface.
Configuring Secure Storage	Describes how to enable and disable secure storage.

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 900 Series ISR Software Configuration Guide (this document), the following reference guides are included:

Type of Document	Links
Cisco 900 Series ISR Hardware Installation Guide	*https://www.cisco.com/c/en/us/td/docs/routers/access/900/hardware/installation/guide/b-cisco-ISR900-series-hig.html*
Regulatory Compliance and Safety Information for Cisco 900 Series Routers	*https://www.cisco.com/c/en/us/td/docs/routers/access/900/regulatory/compliance/900rcsi.html*

Obtaining Documentation and Submitting a Service Request

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

http://www.cisco.com/c/en/us/td/docs/general/whatsnew/whatsnew.html

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

Cisco 900 Series Integrated Services Routers Overview

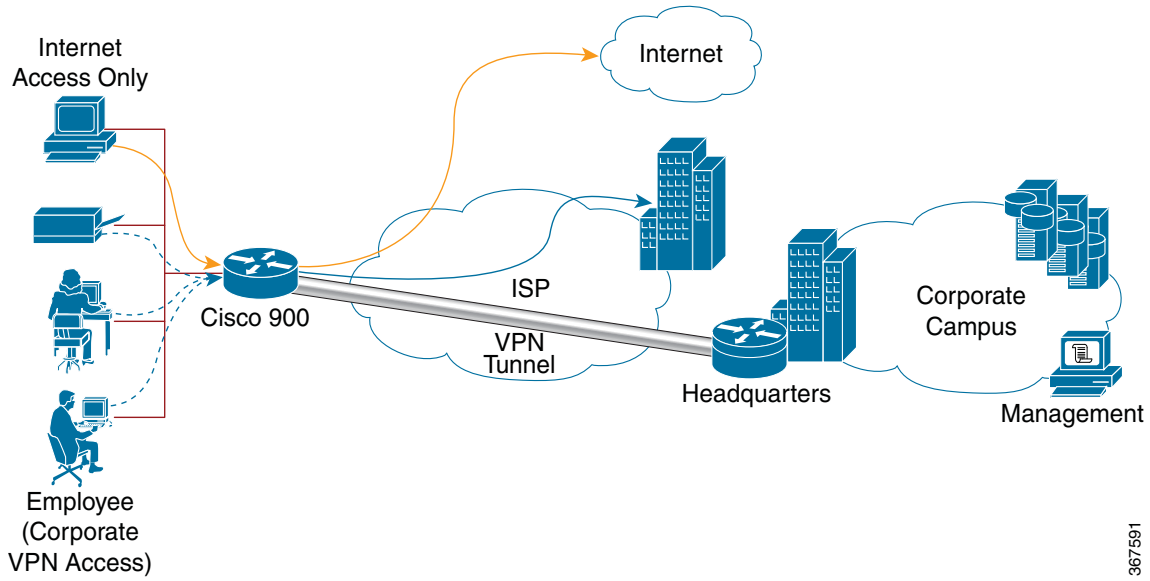
This chapter provides an overview of Cisco 900 Series Integrated Services Routers (ISRs). The chapter contains the following sections:

Overview of the Cisco 900 Series ISR

Cisco 900 Series ISRs are entry level branch routers that provide secure network connectivity for small offices to a central location. These powerful, fixed-configuration routers provide secure broadband and Metro Ethernet and connectivity. Service providers offering managed Ethernet WAN services can deploy them in customer locations as CPE.

Figure 1-1 explains a scenario where the Cisco 900 Series ISR is deployed to provide remote connectivity from a small office to central office over secure VPN tunnels. In this scenario corporate users use a separate VLAN than the Internet users.

Figure 1-1 Cisco 900 Series Deployment Example



Cisco 900 Series ISR Models

Cisco 900 Series ISRs are available in the following models:

- Cisco C921-4P
- Cisco C921J-4P
- Cisco C931-4P

Table 1-1 summarizes the LAN and WAN interface options available for the Cisco 900 Series ISR models.

Table 1-1 LAN and WAN Interfaces of the Cisco 900 Series ISRs

900 Series Models	LAN Interfaces	GE WAN Interfaces
Cisco C921-4P	4 port 10/100/1000 Mbps managed switch	2 Gigabit Ethernet ports
Cisco C921J-4P	4 port 10/100/1000 Mbps managed switch	2 Gigabit Ethernet ports
C921-4PLTEGB	4 port 10/100/1000 Mbps managed switch	2 Gigabit Ethernet ports

900 Series Models	LAN Interfaces	GE WAN Interfaces
C921-4PLTEAU	4 port 10/100/1000 Mbps managed switch	2 Gigabit Ethernet ports
C921-4PLTENA	4 port 10/100/1000 Mbps managed switch	2 Gigabit Ethernet ports
C926-4P	4 port 10/100/1000 Mbps managed switch	1 Gigabit Ethernet ports
C926-4PLTEGB	4 port 10/100/1000 Mbps managed switch	1 Gigabit Ethernet ports
C927-4P	4 port 10/100/1000 Mbps managed switch	1 Gigabit Ethernet ports
C927-4PM	4 port 10/100/1000 Mbps managed switch	1 Gigabit Ethernet ports
C927-4PLTEGB	4 port 10/100/1000 Mbps managed switch	1 Gigabit Ethernet ports
C927-4PMLTEGB	4 port 10/100/1000 Mbps managed switch	1 Gigabit Ethernet ports
C927-4PLTEAU	4 port 10/100/1000 Mbps managed switch	1 Gigabit Ethernet ports
Cisco C931-4P	4 port 10/100/1000 Mbps managed switch	2 Gigabit Ethernet ports

Cisco 900 Series ISR Features

Some of the key features supported by Cisco 900 Series ISRs are:

- Redundant WAN connections for failover protection and load balancing
- Dynamic failover protocols such as Virtual Router Redundancy Protocol (VRRP; RFC 2338) and Hot Standby Router Protocol (HSRP)
- Network perimeter security with integrated application inspection firewall
- Data privacy through high-speed IP Security (IPsec) Triple Data Encryption Standard (3DES) and Advanced Encryption Standard (AES) encryption
- Enforced security policy with intrusion prevention
- Security hardware acceleration
- Next-generation encryption for secure network communications systems, reliable for the next decade
- Supports LAN connections
- Simplifies and centralizes configuration and management of wireless and wireline devices. Supports WLAN services without requiring a wireless LAN controller
- Supports separate console and USB ports

LEDs on the Cisco 900 Series ISR

Table 1-2 describes the LEDs on the Cisco 900 Series ISR.

Table 1-2 LEDs on the Cisco 900 Series ISR

LED	Color	Description
SYS	OFF	System is off.
	Blink	Boot up phase or in ROM Monitor mode.
	Steady on	Normal operation.
	Amber(steady)	Thermal trip.
	Amber(blink)	ROMMON code signing verification failure.
VPN OK	Green	At least one VPN session is active.
	OFF	VPN not connected.
LAN	Green(Solid)	LAN connection is established
	Green (Blinking)	Data transmission is happening on the link.
	OFF	LAN is not connected.
WAN	Green(Solid)	WAN link is established.
	Green (Blinking)	Data transmission is happening on the link.
	OFF	WAN link is not connected.
DSL CD	OFF	Shut.
	Green(Blinking)	Training, or no shut and cable disconnected.
	Green (solid)	Trained.
DSL Data	OFF	Shut.
	Green(Blinking)	TX/RX Data.
RSSI	Green (Solid)	Signal > –60 dBm Very strong signal
	Yellow	60dBm > Signal > -75dBm Strong signal
	Yellow(blinking)	75dBm > Signal > -90dBm Fair signal
	OFF	Signal < –90 dBm Unusable signal
SIM	OFF	No SIM.
	Steady on	SIM present in slot.
	Blink	TXD/RXD data.

Installing the Software

This chapter describes how to upgrade Cisco IOS images, use ROM Monitor, upgrade Field Programmable units, and the licensing packages supported on Cisco ISR 900 Series routers. This chapter includes the following sections:

ROM Monitor

The ROM monitor firmware runs when the router is powered up or reset. The firmware helps to initialize the processor hardware and boot the operating system software. You can use the ROM monitor to perform certain configuration tasks, such as recovering a lost password or downloading Cisco IOS software.

Before using the ROM monitor, you should understand the following concepts:

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 **Ctrl+C** is entered during the first 60 seconds after reloading the router.

To exit ROM monitor mode, see the "Exiting ROM Monitor Mode" section on page 2-10.

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 "Modifying the Configuration Register (confreg)" section on page 2-8.
- 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 "Exiting ROM Monitor Mode" section on page 2-10.
- Disaster recovery—Use the following method 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 WAN port on your router. See the "Exiting ROM Monitor Mode" section on page 2-10.

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 **Ctrl+C** on the PC or terminal.
- To find out which commands are available on your router and to display command syntax options, see the "Modifying the Configuration Register (confreg)" section on page 2-8.

How to Use the ROM Monitor—Typical Tasks

This section provides the following procedures:

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 "Modifying the Configuration Register (confreg)" section on page 2-8.

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 7
- Setting the Configuration Register to Boot to ROM Monitor Mode, page 8

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:

```
Router> enable
Router# reload
Press Ctrl+ C
```

You must press **Ctrl+C** within 60 seconds after you enter the reload command. Before you press **Ctrl+C**, wait for the display to show the five dots as shown in this example:

```
Router#reload
Proceed with reload? [confirm]

*Sep 14 08:52:19.147: %SYS-5-RELOAD: Reload requested by console. Reload Reason: Reload
Command.
System Bootstrap, Version 15.8(3r)M0b, RELEASE SOFTWARE (fc1)
Copyright (c) 2018 by cisco Systems, Inc.
Compiled Mon 03-Sep-2018  9:01:14.57

C931-4P platform with 1048576 Kbytes of main memory

System Integrity Status: 0x00000000
Current image running: Upgrade
Last reset cause: Software initiated

Rom image verified correctly

..... <<<<<<<<<<----------Pressed Ctrl+C to break autoboot and enter ROMMON shell

rommon 1 >
```

What to Do Next

- Proceed to the "Modifying the Configuration Register (confreg)" section on page 2-8.

- 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 entering the **i** or **reset** command, which restarts 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.

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.

This 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 14 08:56:31.265: %SYS-5-CONFIG_I: Configured from console by console
Router#write memory
Building configuration...
[OK][OK]
Router#
*Sep 14 08:56:41.715: %SYS-2-PRIVCFG_ENCRYPT: Successfully encrypted private config file
Router#reload
Proceed with reload? [confirm]

*Sep 14 08:56:47.531: %SYS-5-RELOAD: Reload requested by console. Reload Reason: Reload
Command.
System Bootstrap, Version 15.8(3r)M0b, RELEASE SOFTWARE (fc1)
Copyright (c) 2018 by cisco Systems, Inc.
Compiled Mon 03-Sep-2018  9:01:14.57

C931-4P platform with 1048576 Kbytes of main memory

System Integrity Status: 0x00000000
Current image running: Upgrade
Last reset cause: Software initiated

Rom image verified correctly
```

What to Do Next

Proceed to the "Modifying the Configuration Register (confreg)" section on page 2-8.

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.

Note 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.

In this example, the configuration register is set to boot the system image from flash memory:

```
rommon 3 > confreg 0x2102
```

In this example, no value is entered; therefore, the system prompts for each bit in the register:

```
rommon 3> confreg

Configuration Summary
   (Virtual Configuration Register: 0x100)
enabled are:
[ 0 ] console baud: 9600
boot:..... the ROM Monitor
do you wish to change the configuration? y/n [n]: y
enable "diagnostic mode"? y/n [n]: n
enable "break/abort has effect"? y/n [n]: n
enable "ignore system config info"? y/n [n]: n
change console baud rate? y/n [n]: n
change the boot characteristics? y/n [n]: y
0 = the ROM Monitor
1-15 = boot system
enter boot option [0]: 3
```

Obtaining Information on USB Flash Devices

This example shows how to display the contents of the USB flash device, including directories, files, permissions, and sizes:

```
rommon 3 > dir usbflash0:


Size       Attributes Name
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
8192         drw-     System Volume Information
60865852     -rw-     c900-åuniversalk9_npe-mz.SPA.158-3.M0b
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

This example 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:

```
rommon 2 > dev
Devices in device table:
id name
tftp: network via tftp
```

```
flash: Internal flash drive
usbflash0: External USB drive 0
```

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 entering **i** command or the **reset** command, which restarts 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.

	Command or Action	Purpose
Step 1	**dir flash:**[*directory*] **Example:** `rommon > dir flash:`	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 flash:**[*directory*] [*filename*]
	or
	boot *filename tftpserver*
	or
	boot [*filename*]
	
	Example:
	`ROMMON > boot flash: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).

Upgrading ROMMON using Capsule Upgrade

You can upgrade ROMMON using capsule upgrade. This example shows how to upgrade ROMMON using Capsule Upgrade:

```
router# > upgrade rom-monitor file flash:c900-CapsuleUpdateFile.15.8-3rM0b
```

Note Before you upgrade, make sure that you have the Capsule image '**c900-CapsuleUpdateFile.15.8-3rM0b**' in the router flash.

Use the **showmon -v** command to verify the ROMMON version. This example shows the command output:

```
rommon 1 > showmon -v

System Bootstrap, Version 15.8(3r)M0b, RELEASE SOFTWARE (fc1)
Copyright (c) 2018 by cisco Systems, Inc.
Compiled Mon 03-Sep-2018  9:01:14.57
```

Upgrading the Cisco IOS Software

Your router comes pre-installed with the Cisco IOS image. However, you can install the new version in order to keep router features up to date. This section describes how to upgrade the Cisco Internet Operating System (IOS) software image on a Cisco 900 series ISR.

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?

System images contain the Cisco IOS software. Your router was shipped with an image installed. 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.

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

https://software.cisco.com/download/home

For more information about Loading and Managing System images, go to

https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/fundamentals/configuration/15mt/fundamentals-15-mt-book/cf-config-overview.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 12
- Copying the System Image into Flash Memory, page 13
- Loading the New System Image, page 16
- Saving Backup Copies of Your New System Image and Configuration, page 19

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.

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 flash:** command in privileged EXEC mode to learn the name of the system image file and the **copy flash: 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 flash: 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 flash:
Directory of flash:/

    1  -rw-    64383100  Sep 17 2018 05:58:14 +00:00  c900-universalk9-mz.SSA_09-10
    2  -rw-        1524  Sep 17 2018 05:55:30 +00:00  c900_startupconfig-backup
    3  -rw-         919  Sep 17 2018 05:58:44 +00:00  PSZ22241BW6_20180906052515287.zip

1936031744 bytes total (1871634432 bytes free)
Router#
```

Copying the System Image into Flash Memory

This section describes how to copy the system image into the flash memory card for your router.

Note The router should have sufficient disk or flash memory to store the Cisco IOS. The router should also have sufficient memory (DRAM) to run the Cisco IOS. If the router does not have sufficient memory (DRAM), the router will have boot problems when it boots through the new Cisco IOS.

To copy the system image into the flash memory card for your router, choose one of the following methods:

- Entering ROM Monitor Mode, page 7
- Using the ROM Monitor to Copy the System Image over a Network, page 14
- Loading the New System Image, page 16

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 2-12.
- 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. .

Tip For more detailed information on how to perform the prerequisites, see the *Software Installation and Upgrade Procedure* tech note.

To copy the system image into the flash memory card for your router, follow these 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**: **flash:**

or

copy rcp flash

Use one of these commands to copy a file from a server to flash memory:

```
Router# copy tftp: flash:
```

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 []? c900-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 []? c900-universalk9-mz.bin
```

Step 6 If an error message appears that says, "Not enough space on device", delete files from flash and try again. To delete files from flash, use the **delete flash**: *filename* command.

Step 7 If the error message does not appear, enter **no** when prompted to erase the flash memory before copying:

```
Accessing tftp://10.10.10.2/c900-universalk9-mz.bin...
     Erase flash: before copying? [confirm] no
```

What to Do Next

Proceed to the "Loading the New System Image" section on page 2-16.

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.

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.

Note You can use the **tftpdnld** command only to download files to the router. You cannot use **tftpdnld** to get files from the router.

To download a Cisco IOS software image from a remote TFTP server to the router flash memory by using the tftpdnld ROM monitor command, follow these 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 Use the **set** command to display the ROM monitor environment variables to verify that you have configured them correctly. For example:

```
rommon > set
```

Step 9 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. Using the **-r** option downloads and boots the new software but does not save the software to flash memory.

```
rommon 5 > tftpdnld -r
Attempting to boot from [tftp:]
```

What to Do Next

Proceed to the "Loading the New System Image" section on page 2-16.

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 16
- Loading the New System Image from ROM Monitor Mode, page 18

Loading the New System Image from the Cisco IOS Software

To load the new system image from the Cisco IOS software, follow these steps.

Step 1 **dir flash:**

Use this command to display a list of all files and directories in flash memory:

```
Router# dir flash:

Directory of flash:/

    1  -rw-    64383100  Sep 17 2018 05:58:14 +00:00  c900-universalk9-mz.SSA_09-10
    2  -rw-        1524  Sep 17 2018 05:55:30 +00:00  c900_startupconfig-backup
    3  -rw-         919  Sep 17 2018 05:58:44 +00:00  PSZ22241BW6_20180906052515287.zip

1936031744 bytes total (1871634432 bytes free)
Router#
```

Note Determine whether the new system image is the first file or the only file listed in the **dir flash:** 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 flash:** command output, you do not need to perform the following step.

boot system flash:*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 flash:c900-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 "flash:c900-universalk9-mz.bin"
```

What to Do Next

Proceed to the "Saving Backup Copies of Your New System Image and Configuration" section on page 2-19.

Loading the New System Image from ROM Monitor Mode

To load the new system image from ROM monitor mode, follow these steps:

Step 1 **dir flash:**[*partition-number*:]

Use this command to list files in flash memory:

```
rommon > dir flash:

program load complete, entry point: 0x4000000, size: 0x18fa0
Directory of flash:

2      48296872  -rw-     c900-universalk9-mz.SPA
```

Note whether the new system image is the first file or the only file listed in the **dir flash:** 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 flash:**[*partition-number*:]*filename*

Use this command to force the router to load the new system image:

```
rommon > boot flash:c900-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 flash:** command output, this step is not required.

boot system flash:*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 flash:c900-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 2-19.

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.

	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 flash:** **Example:** `Router# dir flash:`	Displays the layout and contents of a flash memory file system. • Write down the name of the system image file.
Step 4	**copy flash:** {**ftp:** | **rcp:** | **tftp:**} **Example:** `Router# copy flash: 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 flash:** privileged EXEC command to obtain the name of the system image file and the **copy flash: tftp:** privileged EXEC command to copy the system image to a TFTP server. The router uses the default username and password.

```
Router# dir flash:

System flash directory:
File Length Name/status
1 4137888 c920-mz
[4137952 bytes used, 12639264 available, 16777216 total]
16384K bytes of processor board System flash (Read/Write)\

Router# copy flash: tftp:
IP address of remote host [255.255.255.255]? 192.0.0.1
filename to write on tftp host? c920-universalk9-mz
writing c920-mz !!!!...
successful ftp write.
```

Licensing

When you order a new router, it is shipped preinstalled with the software image and the corresponding licenses for the packages and features that you specified. You do not need to activate or register the software before use. You need a license if you are upgrading or installing a new Cisco IOS feature. For more information about the license type, technology package, and installation, see *Software Activation on Cisco Integrated Services Routers and Cisco Integrated Service Routers G2* guide.

Basic Router Configuration

This chapter provides configuration procedures for Cisco 900 series integrated services routers (ISRs). It also includes configuration examples and verification steps whenever possible. This chapter contains the following topics:

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 : 1087 bytes
!
! No configuration change since last restart
! NVRAM config last updated at 06:11:03 UTC Mon Sep 17 2018
!
version 15.8
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Router
!
boot-start-marker
boot-end-marker
!
!
!
no aaa new-model
!
!
!
!
!
!
!
!
!
!
!
!
!
!
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
license udi pid C921J-4P sn PSZ22241C1T
!
!
!
redundancy
!
!
!
!
!
!
interface GigabitEthernet0
no ip address
!
interface GigabitEthernet1
```

```
no ip address
!
interface GigabitEthernet2
no ip address
!
interface GigabitEthernet3
no ip address
!
interface GigabitEthernet4
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet5
ip address 9.6.12.137 255.255.0.0
duplex auto
speed auto
!
interface Vlan1
no ip address
!
ip forward-protocol nd
no ip http server
no ip http secure-server
!
!
ip route 202.153.144.25 255.255.255.255 9.6.0.1
!
!
!
!
control-plane
!
!
vstack
!
line con 0
line vty 0 4
login
transport input none
!
scheduler allocate 20000 1000
!
end

Router#
```

Configuring Global Parameters

This example shows how to configure router global parameters. By configuring global parameters, you specify a name for the router, an encrypted password to prevent unauthorized access to the router, and disables the router from translating unfamiliar words (typos) into IP addresses.

```
Router> enable
Router# configure terminal
Router(config)# hostname Router
Router(config)# enable secret pass123
Router(config)# no ip domain-lookup
Router(config)#
```

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 900 series ISR 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, and 25. A minimum of 50 MB of memory is required for I/O memory.

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

This example shows how to allocate 25% of the DRAM memory to I/O memory and the remaining 75% to processor memory:

```
Router#config terminal
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 ?
<5-25>  percentage of DRAM to use for I/O memory: 5, 10, 15, 20, 25

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
Building configuration...

Current configuration : 1087 bytes
!
! No configuration change since last restart
! NVRAM config last updated at 06:11:03 UTC Mon Sep 17 2018
!
version 15.8
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Router
!
boot-start-marker
boot-end-marker
!
memory-size iomem 25
!
```

Interface Ports

Table 3-1 lists the interfaces that are supported on Cisco 900 series integrated services routers.

Table 3-1 Interfaces by Cisco Router

Slots, Ports, Logical Interface, Interfaces	C921	C931	c941
Onboard GE Switch ports	Gi0,Gi1,Gi2,Gi3	Gi0,Gi1,Gi2,Gi3	Gi0,Gi1,Gi2,Gi3
Onboard GE WAN ports	Gi4,Gi5	Gi4,Gi5	Gi4,Gi5
USB[1]	usbflash0	usbflash0	usbflash0

1. **usbflash0** is the USB interface for all the Cisco 900 series routers.

Configuring Gigabit Ethernet Interfaces

This example shows how to configure the onboard Gigabit Ethernet (GE) interfaces:

```
Router# configure terminal
Router(config)# interface gigabitethernet 4
Router(config-if)# ip address 192.168.12.2 255.255.255.0
Router(config-if)# no shutdown
Router(config-if)# exit
```

Note Switch ports support Auto, Full, and Half Duplex. WAN ports support only Full Duplex.

Use **show interface** command to verify the interface configuration. The following example shows the output for the switch port:

```
Router#show interfaces gig0
GigabitEthernet0 is up, line protocol is up
  Hardware is Gigabit Ethernet, address is 7872.5dab.fe73 (bia 7872.5dab.fe73)
  MTU 1500 bytes, BW 1000000 Kbit/sec, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Full-duplex, 1000Mb/s
  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 multicasts)
     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
     86738 packets output, 9316451 bytes, 0 underruns
     0 output errors, 0 collisions, 2 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
```

The following example shows the output for the WAN port:

```
Router#show interfaces gig5
GigabitEthernet5 is administratively down, line protocol is down
  Hardware is iGbE, address is 7872.5dab.fe75 (bia 7872.5dab.fe75)
  MTU 1500 bytes, BW 1000000 Kbit/sec, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Auto Duplex, Auto Speed, media type is RJ45
  output flow-control is XON, input flow-control is XON
  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 IP multicasts)
     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 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
     1 lost carrier, 0 no carrier, 0 pause output
     0 output buffer failures, 0 output buffers swapped out
Router#
```

Configuring a Loopback Interface

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

This example shows how loopback interface 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
!
```

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

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 900 series routers, the TTY lines are incremented by 1 and start with line number3.

This example 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.

In this 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
!
```

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, gigabitethernet0
```

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, page 30
- Configuring Enhanced Interior Gateway Routing Protocol, page 31

Configuring Routing Information Protocol

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

```
Router> configure terminal
Router(config)# router rip
Router(config-router)# version 2
Router(config-router)# network 192.168.1.1
Router(config-router)# network 10.10.7.1
Router(config-router)# no auto-summary
Router(config-router)# end
```

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

This 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.

```
Router> configure terminal
Router(config)# router eigrp 109
Router(config)# network 192.145.1.0
Router(config)# network 10.10.12.115
Router(config-router)# end
```

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 Switches

This chapter gives an overview of configuration tasks for the Gigabit Ethernet (GE) switch on the Cisco 900 Series ISR.

This chapter contains the following sections:

Configuring VLANs

A VLAN is a switched network that is logically segmented by function, project team, or application, without regard to the physical locations of the users. VLANs have the same attributes as physical LANs, but you can group end stations even if they are not physically located on the same LAN segment. Any switch port can belong to a VLAN, and unicast, broadcast, and multicast packets are forwarded and flooded only to end stations in the VLAN. Each VLAN is considered a logical network, and packets destined for stations that do not belong to the VLAN must be forwarded through a router. A VLAN is a switched network that is logically segmented by function, project team, or application, without regard to the physical locations of the users. VLANs have the same attributes as physical LANs, but you can group end stations even if they are not physically located on the same LAN segment. Any switch port can belong to a VLAN, and unicast, broadcast, and multicast packets are forwarded and flooded only to end stations in the VLAN. Each VLAN is considered a logical network, and packets destined for stations that do not belong to the VLAN must be forwarded through a router.

For detailed information on VLANs, see the following web link:

http://www.cisco.com/c/en/us/td/docs/switches/lan/catalyst3750/software/release/15-0_2_se/configuration/guide/scg3750/swvlan.html

For a sample VLAN configuration, see "Example: VLAN configuration".

Example: VLAN configuration

This example shows how to configure inter-VLAN routing:

```
Router# configure terminal
Router(config)# vlan 1
Router(config)# vlan 2
Router(config)# interface vlan 1
Router(config-if)# ip address 1.1.1.1 255.255.255.0
Router(config-if)# no shut
Router(config-if)# interface vlan 2
Roouter(config-if)# ip address 2.2.2.2 255.255.255.0
Router(config-if)# no shut
Router(config-if)# interface gigabitethernet 0
Router(config-if)# switchport access vlan 1
Router(config-if)# interface gigabitethernet 1
Router(config-if)# switchport access vlan 2
Router(config-if)# exit
```

Configuring VTP

VTP is a Layer 2 messaging protocol that maintains VLAN configuration consistency by managing the addition, deletion, and renaming of VLANs on a network-wide basis. VTP minimizes misconfigurations and configuration inconsistencies that can cause several problems, such as duplicate VLAN names, incorrect VLAN-type specifications, and security violations.

Before you create VLANs, you must decide whether to use VTP in your network. Using VTP, you can make configuration changes centrally on one or more switches and have those changes automatically communicated to all the other switches in the network. Without VTP, you cannot send information about VLANs to other switches.VTP is designed to work in an environment where updates are made on a single switch and are sent through VTP to other switches in the domain. It does not work well in a situation where multiple updates to the VLAN database occur simultaneously on switches in the same domain, which would result in an inconsistency in the VLAN database.

You should understand the following concepts for configuring VTP.

- VTP domain: A VTP domain (also called a VLAN management domain) consists of one switch or several interconnected switches or switch stacks under the same administrative responsibility sharing the same VTP domain name. A switch can be in only one VTP domain. You make global VLAN configuration changes for the domain.
- VTP server: In VTP server mode, you can create, modify, and delete VLANs, and specify other configuration parameters (such as the VTP version) for the entire VTP domain. VTP servers advertise their VLAN configurations to other switches in the same VTP domain and synchronize their VLAN configurations with other switches based on advertisements received over trunk links.VTP server is the default mode.
- VTP client: A VTP client behaves like a VTP server and transmits and receives VTP updates on its trunks, but you cannot create, change, or delete VLANs on a VTP client. VLANs are configured on another switch in the domain that is in server mode.
- VTP transparent: VTP transparent switches do not participate in VTP. A VTP transparent switch does not advertise its VLAN configuration and does not synchronize its VLAN configuration based on received advertisements. However, in VTP version 2 or version 3, transparent switches do forward VTP advertisements that they receive from other switches through their trunk interfaces. You can create, modify, and delete VLANs on a switch in VTP transparent mode.

For detailed information on VTP, see the following web link:

http://www.cisco.com/c/en/us/td/docs/switches/lan/catalyst3750/software/release/15-0_2_se/configuration/guide/scg3750/swvtp.html

For a sample VTP configuration, see "Example: Configuring VTP".

Example: Configuring VTP

This example shows how to configure the switch as a VTP server:

```
Router# configure terminal
Router(config)# vtp mode server
Router(config)# vtp domain Lab_Network
Router(config)# vtp password WATER
Router(config)# exit
```

This example shows how to configure the switch as a VTP client:

```
Router# configure terminal
Router(config)# vtp mode client
Router(config)# exit
```

This example shows how to configure the switch as VTP transparent:

```
Router# configure terminal
Router(config)# vtp mode transparent
Router# exit
```

Configuring 802.1x Authentication

IEEE 802.1x port-based authentication defines a client-server-based access control and authentication protocol to prevent unauthorized clients from connecting to a LAN through publicly accessible ports.The authentication server authenticates each client connected to a switch port before allowing access to any switch or LAN services. Until the client is authenticated, IEEE 802.1x access control allows only Extensible Authentication Protocol over LAN (EAPOL), Cisco Discovery Protocol (CDP), and Spanning Tree Protocol (STP) traffic through the port to which the client is connected. After authentication, normal traffic passes through the port.

With IEEE 802.1x authentication, the devices in the network have specific roles:

- Supplicant—Device (workstation) that requests access to the LAN and switch services and responds to requests from the router. The workstation must be running IEEE 802.1x-compliant client software such as that offered in the Microsoft Windows XP operating system. (The supplicant is sometimes called the client.)
- Authentication server—Device that performs the actual authentication of the supplicant. The authentication server validates the identity of the supplicant and notifies the router whether or not the supplicant is authorized to access the LAN and switch services. The Network Access Device (or Cisco ISR router in this instance) transparently passes the authentication messages between the supplicant and the authentication server, and the authentication process is carried out between the supplicant and the authentication server. The particular EAP method used will be decided between the supplicant and the authentication server (RADIUS server). The RADIUS security system with EAP extensions is available in Cisco Secure Access Control Server Version 3.0 or later. RADIUS operates in a client and server model in which secure authentication information is exchanged between the RADIUS server and one or more RADIUS clients.

- Authenticator—Router that controls the physical access to the network based on the authentication status of the supplicant. The router acts as an intermediary between the supplicant and the authentication server, requesting identity information from the supplicant, verifying that information with the authentication server, and relaying a response to the supplicant. The router includes the RADIUS client, which is responsible for encapsulating and decapsulating the EAP frames and interacting with the authentication server.

For detailed information on how to configure 802.1x port-based authentication, see the following link:

http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/sec_usr_8021x/configuration/15-mt/sec-user-8021x-15-mt-book/config-ieee-802x-pba.html

For a sample 802.1x authentication configuration see "Example: Enabling IEEE 802.1x and AAA on a Switch Port".

Example: Enabling IEEE 802.1x and AAA on a Switch Port

This example shows how to configure Cisco 900 series ISR as 802.1x authenticator.

```
Router> enable
Router# configure terminal
Router(config)# dot1x system-auth-control
Router(config)# aaa new-model
Router(config)# aaa authentication dot1x default group radius
Router(config)# interface gigabitethernet 1
Router(config-if)# switchport mode access
Router(config-if)# authentication port-control auto
Router(config-if)# dot1x pae authenticator
Router(config-if)# end
```

Configuring Spanning Tree Protocol

Spanning Tree Protocol (STP) is a Layer 2 link management protocol that provides path redundancy while preventing loops in the network. For a Layer 2 Ethernet network to function properly, only one active path can exist between any two stations. Multiple active paths among end stations cause loops in the network. If a loop exists in the network, end stations might receive duplicate messages. Switches might also learn end-station MAC addresses on multiple Layer 2 interfaces. These conditions result in an unstable network. Spanning-tree operation is transparent to end stations, which cannot detect whether they are connected to a single LAN segment or a switched LAN of multiple segments.

The STP uses a spanning-tree algorithm to select one switch of a redundantly connected network as the root of the spanning tree. The algorithm calculates the best loop-free path through a switched Layer 2 network by assigning a role to each port based on the role of the port in the active topology:

- Root—A forwarding port elected for the spanning-tree topology
- Designated—A forwarding port elected for every switched LAN segment
- Alternate—A blocked port providing an alternate path to the root bridge in the spanning tree
- Backup—A blocked port in a loopback configuration

The switch that has all of its ports as the designated role or as the backup role is the root switch. The switch that has at least one of its ports in the designated role is called the designated switch.Spanning tree forces redundant data paths into a standby (blocked) state. If a network segment in the spanning tree fails and a redundant path exists, the spanning-tree algorithm recalculates the spanning-tree topology and activates the standby path. Switches send and receive spanning-tree frames, called bridge protocol data units (BPDUs), at regular intervals. The switches do not forward these frames but use them to construct a loop-free path. BPDUs contain information about the sending switch and its ports, including

switch and MAC addresses, switch priority, port priority, and path cost. Spanning tree uses this information to elect the root switch and root port for the switched network and the root port and designated port for each switched segment.

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

For detailed configuration information on STP see the following link:

http://www.cisco.com/c/en/us/td/docs/switches/lan/catalyst3750/software/release/15-0_2_se/configuration/guide/scg3750/swstp.html

For configuration examples, see "Example: Spanning Tree Protocol Configuration".

Example: Spanning Tree Protocol Configuration

This example shows configuring spanning-tree port priority of a Gigabit Ethernet interface. If a loop occurs, spanning tree uses the port priority when selecting an interface to put in the forwarding state.

```
Router# configure terminal
Router(config)# interface gigabitethernet 2
Router(config-if)# spanning-tree vlan 1 port-priority 64
Router(config-if)# end
```

This example shows how to change the spanning-tree port cost of a Gigabit Ethernet interface. If a loop occurs, spanning tree uses cost when selecting an interface to put in the forwarding state.

```
Router#configure terminal
Router(config)# interface gigabitethernet 2
Router(config-if)# spanning-tree cost 18
Router(config-if)# end
```

This example shows configuring the bridge priority of VLAN 10 to 33792:

```
Router# configure terminal
Router(config)# spanning-tree vlan 10 priority 33792
Router(config)# end
```

This example shows configuring the hello time for VLAN 10 being configured to 7 seconds. The hello time is the interval between the generation of configuration messages by the root switch.

```
Router# configure terminal
Router(config)# spanning-tree vlan 10 hello-time 4
Router(config)# end
```

This example shows configuring forward delay time. The forward delay is the number of seconds an interface waits before changing from its spanning-tree learning and listening states to the forwarding state.

```
Router# configure terminal
Router(config)# spanning-tree vlan 10 forward-time 21
Router(config)# end
```

This example shows configuring maximum age interval for the spanning tree. The maximum-aging time is the number of seconds a switch waits without receiving spanning-tree configuration messages before attempting a reconfiguration.

```
Router# configure terminal
Router(config)# spanning-tree vlan 20 max-age 36
Router(config)# end
```

This example shows the switch being configured as the root bridge for VLAN 10, with a network diameter of 4.

```
Router# configure terminal
Router(config)# spanning-tree vlan 10 root primary diameter 4
Router(config)# exit
```

Configuring MAC Address Table Manipulation

The MAC address table contains address information that the switch uses to forward traffic between ports. All MAC addresses in the address table are associated with one or more ports. The address table includes these types of addresses:

- Dynamic address: a source MAC address that the switch learns and then drops when it is not in use. You can use the aging time setting to define how long the switch retains unseen addresses in the table.
- Static address: a manually entered unicast address that does not age and that is not lost when the switch resets.

The address table lists the destination MAC address, the associated VLAN ID, and port number associated with the address and the type (static or dynamic).

See the "Example: MAC Address Table Manipulation" for sample configurations for enabling secure MAC address, creating a statc entry, set the maximum number of secure MAC addresses and set the aging time.

For detailed configuration information on MAC address table manipulation see the following link:

http://www.cisco.com/c/en/us/td/docs/routers/access/interfaces/software/feature/guide/geshwic_cfg.html#wp1048223

Example: MAC Address Table Manipulation

This example shows configuration for enabling secure MAC address option on the port.

```
Router# configure terminal
Router(config)# mac-address-table secure 0004.0005.0006 GigabitEthernet 1 vlan 5
Router(config)# end
```

This example shows creating a static entry in the MAC address table.

```
Router# configure terminal
Router(config)# mac-address-table static 0002.0003.0004 interface GigabitEthernet 2 vlan 3
Router(config)# end
```

This example sets the maximum number of secure MAC addresses to 10.

```
Router# configure terminal
Router(config)# mac-address-table secure maximum 10 GigabitEthernet 1
Router(config)# end
```

This example shows setting the aging timer.

```
Router# configure terminal
Router(config)# mac-address-table aging-time 300
Router(config)# end
```

Configuring MAC Address Notification Traps

MAC address notification enables you to track users on a network by storing the MAC address activity on the switch. Whenever the switch learns or removes a MAC address, an SNMP notification can be generated and sent to the network management system (NMS). If you have many users coming and going from the network, you can set a trap interval time to bundle the notification traps and reduce network traffic. The MAC notification history table stores the MAC address activity for each hardware port for which the trap is enabled. MAC address notifications are generated for dynamic and secure MAC addresses; events are not generated for self addresses, multicast addresses, or other static addresses.

For configuration examples, see "Example: Configuring MAC Address Notification Traps".

Example: Configuring MAC Address Notification Traps

This example shows how to enable the MAC notification trap when a MAC address is added to the interface:

```
Router(config)# interface gigabitethernet 1
Router(config-if)# snmp trap mac-notification added
Router(config-if)# end
```

This example shows how to enable the MAC notification trap when a MAC address is removed from this interface.

```
Router(config)# interface gigabitethernet 1
Router(config-if)# snmp trap mac-notification removed
Router(config-if)# end
```

Configuring the Switched Port Analyzer

You can analyze network traffic passing through ports or VLANs by using SPAN or RSPAN to send a copy of the traffic to another port on the switch or on another switch that has been connected to a network analyzer or other monitoring or security device. SPAN copies (or mirrors) traffic received or sent (or both) on source ports or source VLANs to a destination port for analysis. SPAN does not affect the switching of network traffic on the source ports or VLANs. You must dedicate the destination port for SPAN use. Except for traffic that is required for the SPAN or RSPAN session, destination ports do not receive or forward traffic.

Only traffic that enters or leaves source ports or traffic that enters or leaves source VLANs can be monitored by using SPAN; traffic routed to a source VLAN cannot be monitored. For example, if incoming traffic is being monitored, traffic that gets routed from another VLAN to the source VLAN cannot be monitored; however, traffic that is received on the source VLAN and routed to another VLAN can be monitored.

See Example: SPAN Configuration, page 40 for SPAN configuration examples.

For detailed information on how to configure a switched port analyzer (SPAN) session, see the following web link:

http://www.cisco.com/c/en/us/td/docs/switches/lan/catalyst3750/software/release/15-0_2_se/configuration/guide/scg3750/swspan.html

Example: SPAN Configuration

This example shows how to configure a SPAN session to monitor bidirectional traffic from a Gigabit Ethernet source interface:

```
Router# configure terminal
Router(config)# monitor session 1 source gigabitethernet 1
Router(config)# end
```

This example shows how to configure a gigabit ethernet interface as the destination for a SPAN session:

```
Router# configure terminal
Router(config)# monitor session 1 destination gigabitethernet 2
Router(config)# end
```

This example shows how to remove gigabit ethernet as a SPAN source for SPAN session 1:

```
Router# configure terminal
Router(config)# no monitor session 1 source gigabitethernet 1
Router(config)# end
```

Configuring IGMP Snooping

IGMP snooping constrains the flooding of multicast traffic by dynamically configuring Layer 2 interfaces so that multicast traffic is forwarded to only those interfaces associated with IP multicast devices. As the name implies, IGMP snooping requires the LAN switch to snoop on the IGMP transmissions between the host and the router and to keep track of multicast groups and member ports. When the switch receives an IGMP report from a host for a particular multicast group, the switch adds the host port number to the forwarding table entry; when it receives an IGMP Leave Group message from a host, it removes the host port from the table entry. It also periodically deletes entries if it does not receive IGMP membership reports from the multicast clients.

The multicast router sends out periodic general queries to all VLANs. All hosts interested in this multicast traffic send join requests and are added to the forwarding table entry. The switch creates one entry per VLAN in the IGMP snooping IP multicast forwarding table for each group from which it receives an IGMP join request.

By default, IGMP snooping is globally enabled. When globally enabled or disabled, it is also enabled or disabled in all existing VLAN interfaces. By default, IGMP snooping is enabled on all VLANs, but it can be enabled and disabled on a per-VLAN basis. Global IGMP snooping overrides the per-VLAN IGMP snooping capability. If global snooping is disabled, you cannot enable VLAN snooping. If global snooping is enabled, you can enable or disable snooping on a VLAN basis.

See the “Example: Configuring IGMP Snooping” for a sample configuration on IGMP snooping.

Example: Configuring IGMP Snooping

This example shows how to enable IGMP snooping on a VLAN interface.

```
Router# configure terminal
Router(config)# ip igmp snooping vlan 1
Router# end
```

This example shows how to enable a static connection to a multicast router.

```
Router# configure terminal
Router(config)# ip igmp snooping vlan 1 mrouter interface gigabitethernet 1
Router# end
```

This example shows how to add a port as a member of a multicast group. Ports normally join multicast groups through the IGMP report message, but you can also statically configure a port as a member of a multicast group.

```
Router# configure terminal
Router(config)# ip igmp snooping vlan 1 static 0100.5e02.0203 interface gigabitethernet 1
Router# end
```

Configuring Per-Port Storm Control

Storm control prevents traffic on a LAN from being disrupted by a broadcast, a multicast, or a unicast storm on one of the physical interfaces. A LAN storm occurs when packets flood the LAN, creating excessive traffic and degrading network performance. Errors in the protocol-stack implementation, mistakes in the network configuration, or users issuing a denial-of-service attack can cause a storm.

Storm control (or traffic suppression) monitors packets passing from an interface to the switching bus and determines if the packet is unicast, multicast, or broadcast. The switch counts the number of packets of a specified type received within the 1-second time interval and compares the measurement with a predefined suppression-level threshold.

Storm control uses one of these methods to measure traffic activity:

- Bandwidth as a percentage of the total available bandwidth of the port that can be used by the broadcast, multicast, or unicast traffic
- Traffic rate in packets per second at which broadcast, multicast, or unicast packets are received

With either method, the port blocks traffic when the rising threshold is reached. The port remains blocked until the traffic rate drops below the falling threshold (if one is specified) and then resumes normal forwarding. If the falling suppression level is not specified, the switch blocks all traffic until the traffic rate drops below the rising suppression level. In general, the higher the level, the less effective the protection against broadcast storms.

Note In C900 platform, when you configure the **storm-control action shutdown** command, the state of the port changes to administratively down. Use the **no shutdown** command to manually revert the state of the port.

See the "Example: Per-Port Storm-Control" for a sample configuration on per-port storm control.

Example: Per-Port Storm-Control

This example shows bandwidth-based multicast storm control being enabled at 70 percent on Gigabit Ethernet interface.

```
Router# configure terminal
Router(config)# interface gigabitethernet 2
Router(config-if)# storm-control multicast level 70.0 30.0
Router(config-if)# end
Router# show storm-control multicast
Interface  Filter State   Upper    Lower    Current
---------  -------------  -------  -------  -------
Gi0        inactive       100.00%  100.00%    N/A
Gi1        inactive       100.00%  100.00%    N/A
Gi2        Forwarding      70.00%   30.00%    0.00%
```

Configuring HSRP

The Hot Standby Router Protocol (HSRP) is Cisco's standard method of providing high network availability by providing first-hop redundancy for IP hosts on an IEEE 802 LAN configured with a default gateway IP address. HSRP routes IP traffic without relying on the availability of any single router. It enables a set of router interfaces to work together to present the appearance of a single virtual router or default gateway to the hosts on a LAN. When HSRP is configured on a network or segment, it provides a virtual Media Access Control (MAC) address and an IP address that is shared among a group of configured routers. HSRP allows two or more HSRP-configured routers to use the MAC address and IP network address of a virtual router. The virtual router does not exist; it represents the common target for routers that are configured to provide backup to each other. One of the routers is selected to be the active router and another to be the standby router, which assumes control of the group MAC address and IP address should the designated active router fail.

HSRP uses a priority mechanism to determine which HSRP configured device is to be the default active device. To configure a device as the active device, you assign it a priority that is higher than the priority of all the other HSRP-configured devices. The default priority is 100, so if you configure just one device to have a higher priority, that device will be the default active device. In case of ties, the primary IP addresses are compared, and the higher IP address has priority. If you do not use the standby preempt interface configuration command in the configuration for a router, that router will not become the active router, even if its priority is higher than all other routers.

For more information about configuring HSRP, see the following link:

http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipapp_fhrp/configuration/15-mt/fhp-15-mt-book/fhp-hsrp.html

For a sample HSRP configuration, see “Example: Configuring HSRP”

Example: Configuring HSRP

In this example, Router A is configured to be the active device for group 1 and standby device for group 2. Device B is configured as the active device for group 2 and standby device for group 1.

```
RouterA# configure terminal
RouterA(config)# interface GigabitEthernet 1
RouterA(config-if)# ip address 10.1.0.21 255.255.0.0
RouterA(config-if)# standby 1 priority 110
RouterA(config-if)# standby 1 preempt
RouterA(config-if)# standby 1 ip 10.1.0.3
RouterA(config-if)# standby 2 priority 95
RouterA(config-if)# standby 2 preempt
RouterA(config-if)# standby 2 ip 10.1.0.4
RouterA(config-if)# end

RouterB# configure terminal
RouterB(config)# interface GigabitEthernet 1
RouterB(config-if)# ip address 10.1.0.22 255.255.0.0
RouterB(config-if)# standby 1 priority 105
RouterB(config-if)# standby 1 preempt
RouterB(config-if)# standby 1 ip 10.1.0.3
RouterB(config-if)# standby 2 priority 110
RouterB(config-if)# standby 2 preempt
RouterB(config-if)# standby 2 ip 10.1.0.4
```

Configuring VRRP

The Virtual Router Redundancy Protocol (VRRP) is an election protocol that dynamically assigns responsibility for one or more virtual routers to the VRRP routers on a LAN, allowing several routers on a multiaccess link to utilize the same virtual IP address. A VRRP router is configured to run the VRRP protocol in conjunction with one or more other routers attached to a LAN. In a VRRP configuration, one router is elected as the virtual router master, with the other routers acting as backups in case the virtual router master fails.

An important aspect of the VRRP is VRRP router priority. Priority determines the role that each VRRP router plays and what happens if the virtual router master fails. If a VRRP router owns the IP address of the virtual router and the IP address of the physical interface, this router will function as a virtual router master. Priority also determines if a VRRP router functions as a virtual router backup and the order of ascendancy to becoming a virtual router master if the virtual router master fails. You can configure the priority of each virtual router backup using the **vrrp priority** command.

By default, a preemptive scheme is enabled whereby a higher priority virtual router backup that becomes available takes over for the virtual router backup that was elected to become virtual router master. You can disable this preemptive scheme using the **no vrrp preempt** command. If preemption is disabled, the virtual router backup that is elected to become virtual router master remains the master until the original virtual router master recovers and becomes master again.

The virtual router master sends VRRP advertisements to other VRRP routers in the same group. The advertisements communicate the priority and state of the virtual router master. The VRRP advertisements are encapsulated in IP packets and sent to the IP Version 4 multicast address assigned to the VRRP group. The advertisements are sent every second by default; the interval is configurable.

For more information on VRRP, see the following link:

http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipapp_fhrp/configuration/15-mt/fhp-15-mt-book/fhp-vrrp.html

For a sample VRRP configuration, see “Example: Configuring VRRP”.

Example: Configuring VRRP

In this example, Router A and Router B each belong to two VRRP groups, group1 and group 5. In this configuration, each group has the following properties:

Group 1:

- Virtual IP address is 10.1.0.10.
- Router A will become the master for this group with priority 120.
- Advertising interval is 3 seconds.
- Preemption is enabled.

Group 5:

- Router B will become the master for this group with priority 200.
- Advertising interval is 30 seconds.
- Preemption is enabled.

```
RouterA(config)# interface GigabitEthernet 1
RouterA(config-if)# ip address 10.1.0.2 255.0.0.0
RouterA(config-if)# vrrp 1 priority 120
RouterA(config-if)# vrrp 1 authentication cisco
RouterA(config-if)# vrrp 1 timers advertise 3
```

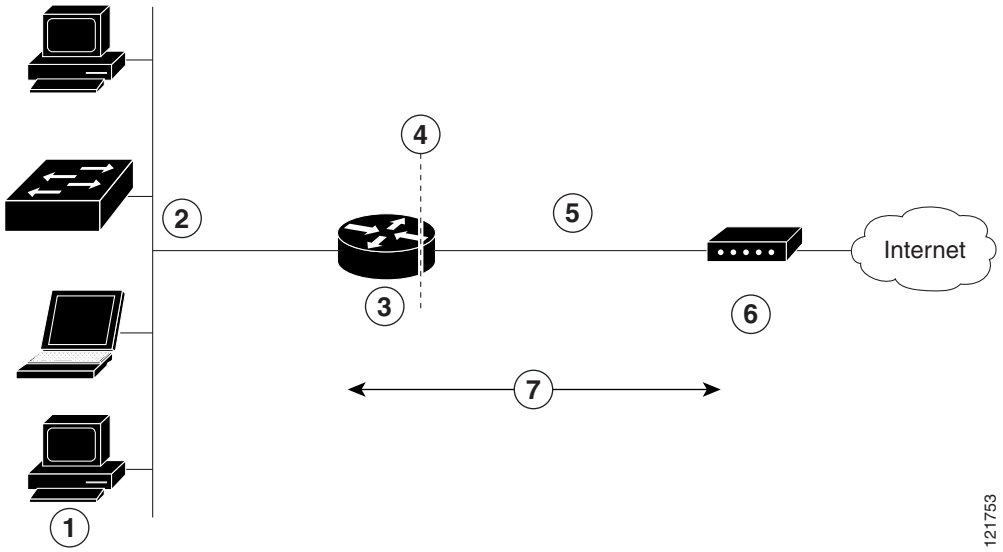
```
RouterA(config-if)# vrrp 1 timers learn
RouterA(config-if)# vrrp 1 ip 10.1.0.10
RouterA(config-if)# vrrp 5 priority 100
RouterA(config-if)# vrrp 5 timers advertise 30
RouterA(config-if)# vrrp 5 timers learn
RouterA(config-if)# vrrp 5 ip 10.1.0.50
RouterA(config-if)# no shutdown

RouterA(config-if)# end

RouterB(config)# interface GigabitEthernet 1
RouterB(config-if)# ip address 10.1.0.1 255.0.0.0
RouterB(config-if)# vrrp 1 priority 100
RouterB(config-if)# vrrp 1 authentication cisco
RouterB(config-if)# vrrp 1 timers advertise 3
RouterB(config-if)# vrrp 1 timers learn
RouterB(config-if)# vrrp 1 ip 10.1.0.10
RouterB(config-if)# vrrp 5 priority 200
RouterB(config-if)# vrrp 5 timers advertise 30
RouterB(config-if)# vrrp 5 timers learn
RouterB(config-if)# vrrp 5 ip 10.1.0.50
RouterB(config-if)# no shutdown
RouterB(config-if)# end
```

Configuring PPP over Ethernet with NAT

This chapter provides an overview of Point-to-Point Protocol over Ethernet (PPPoE) clients and network address translation (NAT) that can be configured on the Cisco 900series Integrated Services Routers (ISRs).

Multiple PCs can be connected to the LAN behind the router. Before the traffic from these PCs is sent to the PPPoE session, it can be encrypted, filtered, and so forth. Figure 5-1 shows a typical deployment scenario with a PPPoE client and NAT configured on the Cisco router.

Figure 5-1 PPP over Ethernet with NAT



1	Multiple networked devices—Desktops, laptop PCs, switches
2	Fast Ethernet LAN interface (inside interface for NAT)
3	PPPoE client—Cisco 900 ISRs
4	Point at which NAT occurs
5	Fast Ethernet WAN interface (outside interface for NAT)
6	Cable modem or other server that is connected to the Internet
7	PPPoE session between the client and a PPPoE server

PPPoE

The PPPoE client feature on the router provides PPPoE client support on Ethernet interfaces. A dialer interface must be used for cloning virtual access. Multiple PPPoE client sessions can be configured on an Ethernet interface, but each session must use a separate dialer interface and a separate dialer pool.

A PPPoE session is initiated on the client side by the Cisco 860 or Cisco 880 ISRs. An established PPPoE client session can be terminated in one of two ways:

- By entering the **clear vpdn tunnel pppoe** command. The PPPoE client session is terminated, and the PPPoE client immediately tries to reestablish the session. This also occurs if the session has a timeout.
- By entering the **no pppoe-client dial-pool** *number* command to clear the session. The PPPoE client does not attempt to reestablish the session.

NAT

NAT (represented as the dashed line at the edge of the Cisco router) signifies two addressing domains and the inside source address. The source list defines how the packet travels through the network.

Configuration Tasks

Perform the following tasks to configure this network scenario:

- Configuring the Virtual Private Dialup Network Group Number
- Configuring Ethernet WAN Interfaces
- Configuring the Dialer Interface
- Configuring Network Address Translation

An example showing the results of these configuration tasks is shown in the "Configuration Example" section on page 48.

Configuring the Virtual Private Dialup Network Group Number

Configuring a virtual private dialup network (VPDN) enables multiple clients to communicate through the router by way of a single IP address.

This example shows how to configure a VPDN:

```
Router(config)# vpdn enable
Router(config)# vpdn-group 1
Router(config-vpdn)# request-dialin
Router(config-vpdn-req-in)# protocol pppoe
Router(config-vpdn-req-in)# exit
Router(config-vpdn)# exit
```

Configuring Ethernet WAN Interfaces

In this scenario, the PPPoE client (your Cisco router) communicates over a 10/100/1000 Mbps-Ethernet interface on both the inside and the outside.

This example shows how to configure the Fast Ethernet WAN interfaces:

```
Router(config)# interface gigabitethernet 4
Router(config-if)# pppoe-client dial-pool-number 1
```

```
Router(config-if)# no shutdown
Router(config-if)# exit
```

Ethernet Operations, Administration, and Maintenance

Ethernet Operations, Administration, and Maintenance (OAM) is a protocol for installing, monitoring, and troubleshooting Ethernet metropolitan-area networks (MANs) and Ethernet WANs. It relies on a new, optional sublayer in the data link layer of the Open Systems Interconnection (OSI) model. The OAM features covered by this protocol are Discovery, Link Monitoring, Remote Fault Detection, Remote Loopback, and Cisco Proprietary Extensions.

For setup and configuration information about Ethernet OAM, see *Using Ethernet Operations, Administration, and Maintenance* at:

https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/cether/configuration/15-mt/ce-15-mt-book/ce-oam.html

Configuring the Dialer Interface

The dialer interface indicates how to handle traffic from the clients, including, for example, default routing information, the encapsulation protocol, and the dialer pool to use. The dialer interface is also used for cloning virtual access. Multiple PPPoE client sessions can be configured on a Fast Ethernet interface, but each session must use a separate dialer interface and a separate dialer pool.

This example shows how to configure a dialer interface for one of the Gigabit Ethernet LAN interfaces on the route:

```
Router(config)# interface dialer 0
Router(config-if)# ip address negotiated
Router(config-if)# ip mtu 1492
Router(config-if)# encapsulation ppp
Router(config-if)# ppp authentication chap
Router(config-if)# dialer pool 1
Router(config-if)# dialer-group 1
Router(config-if)# exit
Router(config)# dialer-list 1 protocol ip permit
Router(config)# ip route 10.10.25.2 255.255.255.255 dialer 0
```

Configuring Network Address Translation

Network Address Translation (NAT) translates packets from addresses that match a standard access list, using global addresses allocated by the dialer interface. Packets that enter the router through the inside interface, packets sourced from the router, or both are checked against the access list for possible address translation. You can configure NAT for either static or dynamic address translations.

This example shows how to configure the outside Gigabit Ethernet WAN interface with dynamic NAT:

```
Router(config)# ip nat pool pool1 192.168.1.0 192.168.2.0 netmask 255.255.252.0
Router(config)# ip nat inside source list 1 interface dialer 0 overload
Router(config)# interface vlan 1
Router(config-if)# ip nat inside
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)# interface gigabitethernet1 Router(config-if)# ip nat outside
Router(config-if)# no shutdown
```

```
Router(config-if)# exit
Router(config)# access-list 1 permit 192.168.1.0 255.255.255.0
```

Note To use NAT with a virtual-template interface, you must configure a loopback interface. See Chapter 3, "Basic Router Configuration," for information on configuring a loopback interface.

Configuration Example

The following configuration example shows a portion of the configuration file for the PPPoE scenario described in this chapter.

The VLAN interface has an IP address of 192.168.1.1 with a subnet mask of 255.255.255.0. NAT is configured for inside and outside

Note Commands marked by "**(default)**" are generated automatically when you run the **show running-config** command.

```
vpdn enable
vpdn-group 1
request-dialin
protocol pppoe
!
interface vlan 1
ip address 192.168.1.1 255.255.255.0
no ip directed-broadcast (default)
ip nat inside
interface gigabitethernet 4
no ip address
no ip directed-broadcast (default)
ip nat outside
pppoe enable group global
pppoe-client dial-pool-number 1
no sh
!
interface dialer 0
ip address negotiated
ip mtu 1492
encapsulation ppp
ppp authentication chap
dialer pool 1
dialer-group 1
!
dialer-list 1 protocol ip permit
ip nat inside source list 1 interface dialer 0 overload
ip classless (default)
ip route 10.10.25.2 255.255.255.255 dialer 0
ip nat pool pool1 192.168.1.0 192.168.2.0 netmask 255.255.252.0
ip nat inside source list acl1 pool pool1
!
```

Verifying Your Configuration

Use the **show ip nat statistics** command in privileged EXEC mode to verify the PPPoE with NAT configuration. You should see verification output similar to the following example:

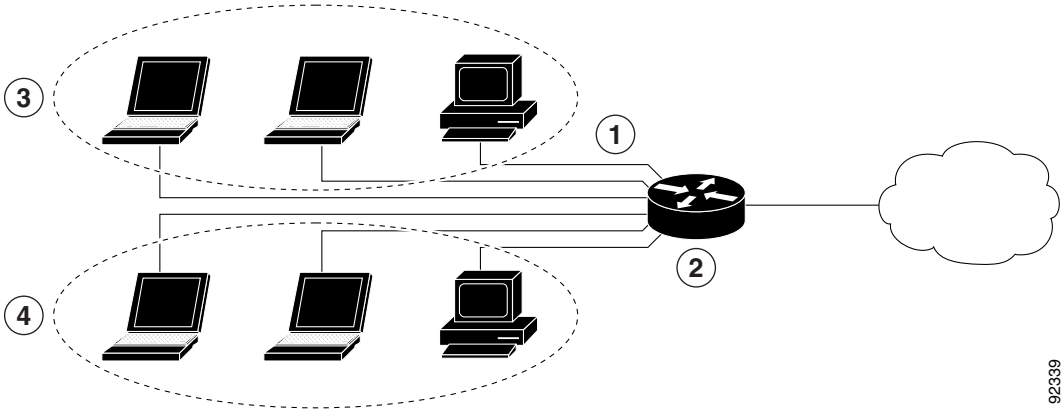
```
Router# show ip nat statistics
Total active translations: 0 (0 static, 0 dynamic; 0 extended)
Outside interfaces:
  gigabitethernet4
Inside interfaces:
  Vlan1
Hits: 0  Misses: 0
CEF Translated packets: 0, CEF Punted packets: 0
Expired translations: 0
Dynamic mappings:
-- Inside Source
[Id: 1] access-list 1 interface Dialer0 refcount 0
Queued Packets: 0
```

Configuring a LAN with DHCP and VLANs

The Cisco 900 series Integrated Services Routers (ISRs) support clients on both physical LANs and VLANs. The routers can use the Dynamic Host Configuration Protocol (DHCP) to enable automatic assignment of IP configurations for nodes on these networks.

Figure 6-1 shows a typical deployment scenario with two physical LANs connected by the router and two VLANs.

Figure 6-1 Physical and Virtual LANs with DHCP Configured on the Cisco Router



1	Fast Ethernet LAN (with multiple networked devices)
2	Router and DHCP server—Cisco 900 series access router—connected to the Internet
3	VLAN 1
4	VLAN 2

DHCP

DHCP, which is described in RFC 2131, uses a client/server model for address allocation. As an administrator, you can configure your Cisco 900 series router to act as a DHCP server, providing IP address assignment and other TCP/IP-oriented configuration information to your workstations. DHCP frees you from having to manually assign an IP address to each client.

When you configure a DHCP server, you must configure the server properties, policies, and DHCP options.

Note Whenever you change server properties, you must reload the server with the configuration data from the Network Registrar database.

VLANs

The Cisco 900 series access routers support four Gigabit Ethernet ports on which you can configure VLANs.

VLANs enable networks to be segmented and formed into logical groups of users, regardless of the user's physical location or LAN connection.

Configuration Tasks

Perform the following tasks to configure this network scenario:

- Configuring DHCP
- Configuring VLANs

Note The procedures in this chapter assume you have already configured basic router features as well as PPPoE or PPPoA with NAT. If you have not performed these configurations tasks, see Chapter 3, "Basic Router Configuration," and Chapter 5, "Configuring PPP over Ethernet with NAT," as appropriate for your router.

Configuring DHCP

This example shows a portion of the configuration file for the DCHP configuration described in this chapter.

```
Router(config)# ip domain name smallbiz.com
Router(config)# ip name-server 192.168.11.12
Router(config)# ip dhcp excluded-address 192.168.9.0
Router(config)# ip dhcp pool dpool1
Router(config-dhcp)# import all
Router(config-dhcp)# network 10.10.0.0 255.255.255.0
Router(config-dhcp)# default-router 10.10.10.10
Router(config-dhcp)# dns-server 192.168.35.2
Router(config-dhcp)# domain-name cisco.com
Router(config-dhcp)# exit
```

Use the following commands to view your DHCP configuration.

- **show ip dhcp import**—Displays the optional parameters imported into the DHCP server database.
- **show ip dhcp pool**—Displays information about the DHCP address pools.
- **show ip dhcp server statistics**—Displays the DHCP server statistics, such as the number of address pools and bindings.

```
Router# show ip dhcp import
Address Pool Name: dpool1

Router# show ip dhcp pool
```

```
Pool dpool1 :
 Utilization mark (high/low)    : 100 / 0
 Subnet size (first/next)       : 0 / 0
 Total addresses                : 254
 Leased addresses               : 0
 Pending event                  : none
 1 subnet is currently in the pool :
 Current index        IP address range                    Leased addresses
 10.10.0.1            10.10.0.1        - 10.10.0.254       0

Router# show ip dhcp server statistics
Memory usage         15419
Address pools        1
Database agents      0
Automatic bindings   0
Manual bindings      0
Expired bindings     0
Malformed messages   0
Secure arp entries   0

Message              Received
BOOTREQUEST          0
DHCPDISCOVER         0
DHCPREQUEST          0
DHCPDECLINE          0
DHCPRELEASE          0
DHCPINFORM           0

Message              Sent
BOOTREPLY            0
DHCPOFFER            0
DHCPACK              0
DHCPNAK              0
Router#
```

Configuring VLANs

This example shows how to configure VLANs on your router:

```
Router(config)# vlan 2
Router(config)# exit
```

Assign a Switch Port to a VLAN

This example shows how to assign a switch port to a VLAN:

```
Router(config)# interface gigabitethernet 2
Router(config-if)# switchport access vlan 2
Router(config-if)# end
Router(config-if)#
```

Use the following commands to view your VLAN configuration.

- **show**—Entered from VLAN database mode. Displays summary configuration information for all configured VLANs.
- **show vlan-switch**—Entered from privileged EXEC mode. Displays detailed configuration information for all configured VLANs.

```
Router# vlan database
Router(vlan)# show

  VLAN ISL Id: 1
    Name: default
    Media Type: Ethernet
    VLAN 802.10 Id: 100001
    State: Operational
    MTU: 1500
    Translational Bridged VLAN: 1002
    Translational Bridged VLAN: 1003

  VLAN ISL Id: 2
    Name: VLAN0002
    Media Type: Ethernet
    VLAN 802.10 Id: 100002
    State: Operational
    MTU: 1500

  VLAN ISL Id: 3
    Name: red-vlan
    Media Type: Ethernet
    VLAN 802.10 Id: 100003
    State: Operational
    MTU: 1500

  VLAN ISL Id: 1002
    Name: fddi-default
    Media Type: FDDI
    VLAN 802.10 Id: 101002
    State: Operational
    MTU: 1500
    Bridge Type: SRB
    Translational Bridged VLAN: 1
    Translational Bridged VLAN: 1003

  VLAN ISL Id: 1003
    Name: token-ring-default
    Media Type: Token Ring
    VLAN 802.10 Id: 101003
    State: Operational
    MTU: 1500
    Bridge Type: SRB
    Ring Number: 0
    Bridge Number: 1
    Parent VLAN: 1005
    Maximum ARE Hop Count: 7
    Maximum STE Hop Count: 7
    Backup CRF Mode: Disabled
    Translational Bridged VLAN: 1
    Translational Bridged VLAN: 1002

  VLAN ISL Id: 1004
    Name: fddinet-default
    Media Type: FDDI Net
    VLAN 802.10 Id: 101004
    State: Operational
    MTU: 1500
    Bridge Type: SRB
    Bridge Number: 1
    STP Type: IBM

  VLAN ISL Id: 1005
    Name: trnet-default
```

```
    Media Type: Token Ring Net
    VLAN 802.10 Id: 101005
    State: Operational
    MTU: 1500
    Bridge Type: SRB
    Bridge Number: 1
    STP Type: IBM

Router# show vlan-switch

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0, Fa1, Fa3
2    VLAN0002                         active    Fa2
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------
1    enet  100001     1500  -      -      -        -    -        1002   1003
2    enet  100002     1500  -      -      -        -    -        0      0
1002 fddi  101002     1500  -      -      -        -    -        1      1003
1003 tr    101003     1500  1005   0      -        -    srb      1      1002
1004 fdnet 101004     1500  -      -      1        ibm  -        0      0
1005 trnet 101005     1500  -      -      1        ibm  -        0      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 900 Integrated Services Router (ISR).

This chapter contains the following sections:

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

This example shows how to configure the IEEE 802.1X on the Cisco 900 ISR:

```
Router> enable
Router# configure terminal
Router(config)# interface gigabitethernet 0
Router(config-if)# authentication port-control auto
Router(config-if)#dot1x pae authenticator
Router(config-if)# end
Router#
```

Use the **show authentication sessions** command to verify the configuration:

```
Router#show authentication sessions

Interface      MAC Address     Method   Domain   Status         Session ID
Gi1          000d.e105.c771  dot1x    DATA     Authz Success  0303030300000000000BA04

Router#show authentication sessions interface Gi1
           Interface:  GigabitEthernet1
          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

Router#
```

Configuring the MAC Authentication Bypass (MAB)

This example shows how to configure the MAB:

```
Router> enable
Router# configure terminal
Router(config)# interface gigabitethernet 0
Router(config-if)# authentication port-control auto
Router(config-if)# mab
Router(config-if)# end
Router#
```

Use the **show authentication sessions** command to verify the configuration:

```
Router#show authentication sessions

Interface      MAC Address     Method   Domain   Status         Session ID
Gi1          0201.0201.0201  mab      DATA     Authz Success  0303030300000004002500A8
```

```
Router#show authentication sessions interface Gi1
            Interface:  GigabitEthernet1
          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:  0303030300000004002500A8
     Acct Session ID:  0x00000007
              Handle:  0x3D000005

Runnable methods list:
       Method   State
       mab      Authc Success

Router#
```

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

This example shows how to configure the Controlling Port Authorization state:

```
Router> enable
Router# configure terminal
Router(config)# interface gigabitethernet 0
Router(config-if)# authentication port-control {auto | force-authorized |
force-unauthorized}
Router(config-if)# mab
Router(config-if)# end
Router#
```

Use the **show authentication sessions** and **show dot1x** commands to verify the Controlling Port Authorization state:

```
Router#show authentication sessions

Interface      MAC Address     Method   Domain   Status         Session ID
Gi1          (unknown)       dot1x    DATA     Authz Success  0303030300000000A002CFCBC

Router#show authentication sessions interface gi1
            Interface:  GigabitEthernet1
          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

Router#show dot1x interface g0
Dot1x Info for GigabitEthernet0
-----------------------------------
PAE                       = AUTHENTICATOR
PortControl               = FORCE_AUTHORIZED
ControlDirection          = Both
HostMode                  = SINGLE_HOST
QuietPeriod               = 60
ServerTimeout             = 0
SuppTimeout               = 30
ReAuthMax                 = 2
MaxReq                    = 2
TxPeriod                  = 30

Router#show authentication sessions

Interface      MAC Address     Method   Domain   Status         Session ID
Gi1          (unknown)       dot1x    DATA     Authz Failed   0303030300000009002AB7FC

Router#show authentication sessions interface gi0
            Interface:  GigabitEthernet0
```

```
           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:  030303030000000009002AB7FC
      Acct Session ID:  0x0000000C
               Handle:  0x8B00000A

Runnable methods list:
       Method   State
       dot1x    Authc Failed

Router#show dot1x interface g0
Dot1x Info for GigabitEthernet0
-----------------------------------
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

This example shows how to configure Open Access:

```
Router> enable
Router# configure terminal
Router(config)# interface gigabitethernet 0
Router(config-if)# authentication open
Router(config-if)# end
Router#
```

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)

This example shows how to configure Control-Direction (Wake-on-LAN):

```
Router> enable
Router# configure terminal
Router(config)# interface gigabitethernet 0
Router(config-if)# authentication control-direction both
Router(config-if)# end
Router#
```

Use the **show authentication sessions** and **show dot1x** commands to verify the default control-direction setting-both:

```
Router#show authentication sessions interface Gi0
            Interface:  GigabitEthernet0
          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:  03030303000000000000BA04
      Acct Session ID:  0x00000001
               Handle:  0x6D000001

Runnable methods list:
       Method   State
       dot1x    Authc Success

Router#

Router#show dot1x int g0
Dot1x Info for GigabitEthernet0
-----------------------------------
PAE                       = AUTHENTICATOR
PortControl               = AUTO
ControlDirection          = Both
HostMode                  = SINGLE_HOST
QuietPeriod               = 60
ServerTimeout             = 0
SuppTimeout               = 30
ReAuthMax                 = 2
MaxReq                    = 2
TxPeriod                  = 30
```

Use the show authentication sessions and show dot1x commands to verify the authentication control-direction setting-in:

```
Router#show authentication sessions interface gi0
            Interface:  GigabitEthernet0
          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

Router#show dot1x interface g0
Dot1x Info for GigabitEthernet0
-----------------------------------
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.

Configuring Security Features

This chapter describes how to configure security features on a Cisco 900 Series Integrated Services Routers (ISRs). This chapter contains the following sections:

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 *SSL VPN Configuration Guide, Cisco IOS Release 15M&T* at:

https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/sec_conn_sslvpn/configuration/15-mt/sec-conn-sslvpn-15-mt-book/sec-conn-sslvpn-ssl-vpn.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* at:

https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/security/config_library/15-mt/secuser-15-mt-library.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 feature document at:
https://www.cisco.com/c/en/us/td/docs/ios/sec_user_services/configuration/guide/convert/user_security/sec_autosecure.html

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 *Security Configuration Guide: Access Control Lists, Cisco IOS Release 15M&T* at:

https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/sec_data_acl/configuration/15-mt/sec-data-acl-15-mt-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 8-1 lists the commands used to configure access lists.

Table 8-1 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**}

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 *Security Configuration Guide: Access Control Lists, Cisco IOS Release 15M&T* at:

https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/sec_data_acl/configuration/15-mt/sec-data-acl-15-mt-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 *Security Configuration Guide: Zone-Based Policy Firewall, Cisco IOS Release 15M&T* at: https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/sec_data_zbf/configuration/15-mt/sec-data-zbf-15-mt-book/sec-zone-pol-fw.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 *Security Configuration Guide: Zone-Based Policy Firewall, Cisco IOS Release 15M&T* at: https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/sec_data_zbf/configuration/15-mt/sec-data-zbf-15-mt-book/fw-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 *Security Configuration Guide: Zone-Based Policy Firewall, Cisco IOS Release 15M&T "* at: https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/sec_data_zbf/configuration/15-mt/sec-data-zbf-15-mt-book/sec-zone-pol-fw.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 theconnection 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 Intrusion Prevention System Configuration Guide, Cisco IOS Release 15MT at:

https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/sec_data_ios_ips/configuration/15-mt/sec-data-ios-ips-15-mt-book/sec-ips5-sig-fs-ue.html.

Content Filtering

Cisco 900 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:
https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/sec_data_zbf/configuration/15-mt/sec-data-zbf-15-mt-book/subscrip-cont-filter.html.

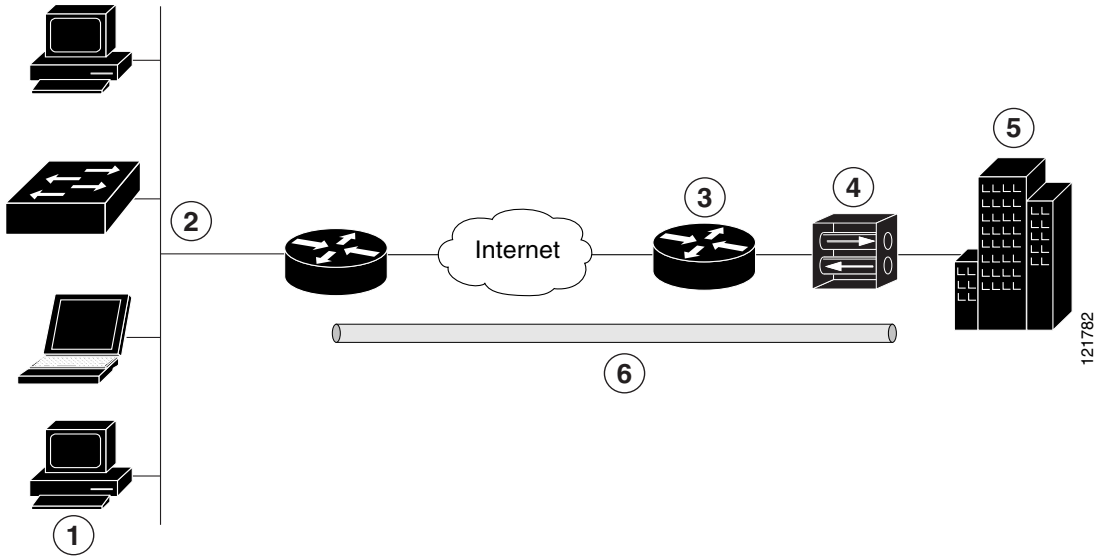
Configuring VPN

A Virtual Private Network (VPN) connection provides a secure connection between two networks over a public network such as the Internet. Cisco 900 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 8-1 shows a typical deployment scenario.

Figure 8-1 Remote Access VPN Using IPSec Tunnel



1	Remote networked users
2	VPN client—Cisco 900 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.

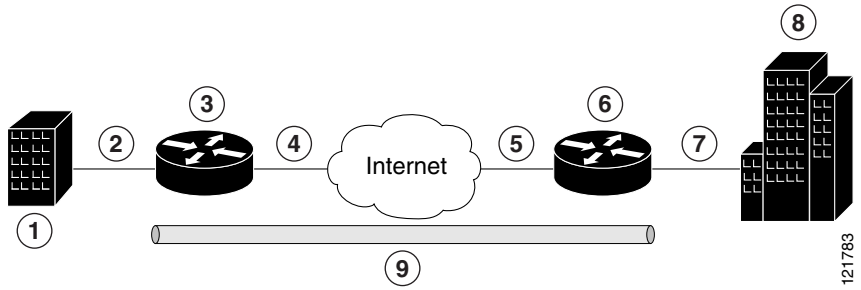
Cisco900 series ISRs can be also configured to act as Cisco Easy VPN servers, letting authorized Cisco Easy VPN clients establish dynamic VPN tunnels to the connected network. For information on configuring Cisco Easy VPN servers, see the *Easy VPN Server* feature at:

https://www.cisco.com/c/en/us/td/docs/ios/sec_secure_connectivity/configuration/guide/convert/sec_easy_vpn_15_1_book.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 8-2 shows a typical deployment scenario.

Figure 8-2 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 900 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 *Security for VPNs with IPsec Configuration Guide, Cisco IOS Release 15M&T* at: https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/sec_conn_vpnips/configuration/15-mt/sec-sec-for-vpns-w-ipsec-15-mt-book.html.

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 *Dynamic Multipoint VPN Configuration Guide, Cisco IOS Release 15M&T* at:

https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/sec_conn_dmvpn/configuration/15-mt/sec-conn-dmvpn-15-mt-book/sec-conn-dmvpn-dmvpn.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 *https://www.cisco.com/en/US/docs/ios-xml/ios/sec_conn_getvpn/configuration/15-2mt/sec-get-vpn.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.

For additional information about Cisco TrustSec, see https://www.cisco.com/c/en/us/td/docs/switches/lan/trustsec/configuration/guide/trustsec/config.html

Crypto Engine Throughput Policing

There are two types of crypto throughput policing: Packet Rate Policing and Bit Rate Policing.

Packet Rate Policing

Cisco 921J router supports packet rate (packets/second) policing. The actual bit rate throughput (bits/second) depends on the packet sizes.

SKU	Packet Rate Limit (pps)
C921J	85616

Bit Rate Policing

Cisco 931 and C921 routers support bit rate (bits/second) policing.

SKU	Bit Rate Limit (Mbps)
C931	250
C921	150

Use the **show crypto engine accelerator statistic** command to see the packet drops due to policing. This example shows the output of the command for Cisco 921J router:

```
router#show crypto engine accelerator statistic

Device:   Onboard VPN
Location: Onboard: 0
        :Statistics for encryption device since the last clear
         of counters 1440809 seconds ago
            95487781408 packets in               95486424592 packets out
         33644619163784 bytes in              33644414868202 bytes out
                  66273 paks/sec in                   66272 paks/sec out
                 186809 Kbits/sec in                  186808 Kbits/sec out
              497655085 packets decrypted           499488995 packets encrypted
         18274163849048 bytes before decrypt   15370455314736 bytes encrypted
         15369938845298 bytes decrypted        18274476022904 bytes after encrypt
                Last 5 minutes:
               26066232 packets in                 26066232 packets out
                  86887 paks/sec in                   86887 paks/sec out
              250994648 bits/sec in                250995151 bits/sec out
             4247760866 bytes decrypted           4248382774 bytes encrypted
              114804347 Kbits/sec decrypted         114821156 Kbits/sec encrypted

Onboard VPN:
        ds: 0x10E31D10        idb:0x0EA74988

        Statistics for Virtual Private Network (VPN) Module:

        RAW API handler invoked:       997144123
        Available IPSEC static pak:           957
        Packets returned from drops:     1356816
        Pkts returned from raw rtrn:   997144110
        Available Pre-batch entries:          959

        Particle copy:                    0
```

```
        Particle swap:                    0
        Particle reparent:        998500926
        Packet overruns:                  0
        Output packets dropped:           0

        1440809 seconds since last clear of counters

CE Status Related Packet Stats
================================
           Crypto Internal Error : 1
                 Resource Errors : 1356815

SKU information:
=================
Max Bandwidth:250 Mbps  IMIX-size:365 Packets-per-second (PPS):85616
Statistics information:
  Packets handled 95486424673
  Packets dropped 1356815
```

This example shows the output of the command for Cisco 931 router:

```
Router#show crypto engine accelerator statistic
Device:   Onboard VPN
Location: Onboard: 0
               :Statistics for encryption device since the last clear
                of counters 2569 seconds ago
                    151982466 packets in                142427991 packets out
                  54548953852 bytes in                51715073454 bytes out
                        59160 paks/sec in                    55441 paks/sec out
                       169858 Kbits/sec in                  161033 Kbits/sec out
                     67912187 packets decrypted           74515857 packets encrypted
                  27818735160 bytes before decrypt      26730230184 bytes encrypted
                  22213021398 bytes decrypted           29502075720 bytes after encrypt
                               Last 5 minutes:
                     22436614 packets in                  22436387 packets out
                        74788 paks/sec in                    74787 paks/sec out
                    219207775 bits/sec in                219204787 bits/sec out
                   3667993316 bytes decrypted            3670433984 bytes encrypted
                     99134954 Kbits/sec decrypted          99200918 Kbits/sec encrypted

Onboard VPN:
               ds: 0x12EA45B8        idb:0x123EF0D0

               Statistics for Virtual Private Network (VPN) Module:

               RAW API handler invoked:       142428045
               Available IPSEC static pak:           957
               Packets returned from drops:     9554448
               Pkts returned from raw rtrn:   142428044
               Available Pre-batch entries:          959

               Particle copy:                      0
               Particle swap:               70265739
               Particle reparent:           81716753
               Packet overruns:                    0
               Output packets dropped:             0

               2569 seconds since last clear of counters

CE Status Related Packet Stats
================================
           Crypto Internal Error : 1
                 Resource Errors : 9554447
```

```
SKU information:
================
Max Bandwidth:250 Mbps
Statistics information:
  Packets handled 142428045
  Packets dropped 9554447
```

This example shows the output of the command for Cisco 921 router:

```
Router#show crypto engine accelerator statistic
Device:   Onboard VPN
Location: Onboard: 0
               :Statistics for encryption device since the last clear
                of counters 3014 seconds ago
                     36412147 packets in                  33336964 packets out
                  13812996658 bytes in                 11412671776 bytes out
                        12081 paks/sec in                     11060 paks/sec out
                        36661 Kbits/sec in                    30290 Kbits/sec out
                     26024533 packets decrypted            7312452 packets encrypted
                  10920338080 bytes before decrypt       2892660426 bytes encrypted
                   8516694798 bytes decrypted            2895986384 bytes after encrypt
                               Last 5 minutes:
                     14963577 packets in                  12694499 packets out
                        49878 paks/sec in                    42314 paks/sec out
                    146860315 bits/sec in                123543958 bits/sec out
                   2179066680 bytes decrypted            2349328596 bytes encrypted
                     58893694 Kbits/sec decrypted          63495367 Kbits/sec encrypted

Onboard VPN:
               ds: 0x135C41CC        idb:0x132B2FE0

               Statistics for Virtual Private Network (VPN) Module:

               RAW API handler invoked:        33336985
               Available IPSEC static pak:          957
               Packets returned from drops:     3075165
               Pkts returned from raw rtrn:    33336985
               Available Pre-batch entries:         959

               Particle copy:                       0
               Particle swap:                36412150
               Particle reparent:                   0
               Packet overruns:                     0
               Output packets dropped:              0

               3014 seconds since last clear of counters

CE Status Related Packet Stats
================================
                Resource Errors : 3075165

SKU information:
================
Max Bandwidth:150 Mbps
Statistics information:
  Packets handled 33336985
  Packets dropped 3075165
```

Configuring VDSL2 and ADSL2/2+

This chapter describes how to configure multimode VDSL2 and ADSl2+ WAN connectivity on a Cisco 900 series ISR. The VDSL2 and ADSl2+ WAN connectivity provides high-speed digital data transmission between customer premises equipment (CPE) and the central office. This chapter contains the following sections:

Overview

Organization needs high speed digital data transmission to operate between their data equipment and central office, usually located at the telecom service provider premises. The Cisco multimode VDSL2 and ADSL1/2/2+ provides 1-port (2-pair) multimode VDSL2 and ADSL2+ WAN connectivity. This connectivity in combination with Cisco 900 Series Integrated Service Routers, provides high-speed digital data transmission between customer premises equipment (CPE) and the central office.

The following table describes the VDSL2 and ADSL2/2+ Variants:

Product Number	Description
C926-4P Annex B	1-port (1-pair) VDSL2/ADSL2+ over ISDN • ADSL1/2/2+ Annex B, non-optimized ADSL2/2+ Annex J • VDSL2 over ISDN Band Plans (8b to 17a) with Vectoring
C927-4P Annex A	1-port (2-pair) VDSL2/ADSL2+ over POTS • VDSL2 over POTS Band Plans – VDSL2 profiles: 8a, 8b, 8c, 8d, 12a, 12b, 17a – Vectoring • ADSL1/2/2+ Annex A, ADSL2 Annex L, non-optimized ADSL2/2+ Annex M
C927-4PM Annex M	1-port (2-pair) VDSL2/ADSL2+ over POTS with Annex M • VDSL2 over POTS Band Plans – VDSL2 profiles: 8a, 8b, 8c, 8d, 12a, 12b, 17a – Vectoring • Optimized ADSL2/2+ Annex M • ADSL/ADSL2/2+ Annex A/M

Configuring DSL

Cisco 900 Series Integrated Services Routers (ISRs) support asymmetric digital subscriber line (ADSL) 2/2+ and very high speed digital subscriber line 2 (VDSL2) transmission modes, also called multimode.

DSL Configuration Restrictions

- Cisco 900 Series Router supports only Pair 0.
- VDSL mode bonding is not supported. 30a profile is not supported.

Configuring ADSL Mode

Perform the following tasks to configure ADSL mode:

Configuring ADSL Auto Mode

Note Configure the DSLAM in ADSL mode prior to configuring the router.

This example shows how to configure the ADSL controller to auto mode:

```
Router> enable
Router# configure terminal
Router(config)# controller vdsl 0
Router(config-controller)# operating mode auto
Router(config-controller)# end
Router#
```

Configuring CPE and Peer for ADSL Mode

When configuring for ADSL, the ATM main interface or ATM sub-interface must be configured with a PVC and an IP address, perform a **no shutdown** command on the interface if needed.

Configuring the ATM CPE side

This example shows how to configure the ATM CPE side:

```
Router> enable
Router# configure terminal
Router(config)# interface atm0
Router(config-if)# no shutdown
Router(config-if)# interface ATM0.1 point-to-point
Router(config-subif)# ip address 30.0.0.1 255.255.255.0
Router(config-subif)# pvc 13/32
Router(config-if-atm-vc)# protocol ip 30.0.0.2 broadcast
Router(config-if-atm-vc)# end
```

Configuring the ATM Peer side

This example shows how to configure the ATM peer side:

```
Router> enable
Router# configure terminal
Router(config)# interface atm0
Router(config-if)# no shutdown
Router(config-if)# interface ATM0.1 point-to-point
Router(config-subif)# ip address 30.0.0.2 255.255.255.0
Router(config-subif)# pvc 13/32
Router(config-if-atm-vc)# protocol ip 30.0.0.1 broadcast
```

```
Router(config-if-atm-vc)# end
Router#
```

ADSL Configuration Example

This example shows a typical ADSL2+ configuration set to auto mode.

```
Router# show running
Building configuration...

Current configuration : 1519 bytes
!
! Last configuration change at 08:46:20 UTC Fri Jan 11 2019
!
version 15.8
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Router
!
boot-start-marker
boot system flash:c900-universalk9-mz.SPA.158-3.M1
boot-end-marker
!
!
!
no aaa new-model
!
!
!
!
!
!
!
!
!
!
!
!
!
!
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
license udi pid C927-4P sn FGL22511283
!
!
!
redundancy
!
!
controller VDSL 0
!
!
!
!
!
```

```
interface ATM0
 no ip address
 shutdown
 no atm ilmi-keepalive
!
interface ATM0.1 point-to-point
 ip address 30.0.0.1 255.255.255.0
 pvc 13/32
  protocol ip 30.0.0.2 broadcast
 !
!
interface Ethernet0
 no ip address
!
interface GigabitEthernet0
 no ip address
!
interface GigabitEthernet1
 no ip address
!
interface GigabitEthernet2
 no ip address
!
interface GigabitEthernet3
 no ip address
!
interface GigabitEthernet4
 ip address 9.6.9.29 255.255.0.0
 duplex auto
 speed auto
!
interface Vlan1
 no ip address
!
ip forward-protocol nd
no ip http server
no ip http secure-server
!
!
ip tftp source-interface GigabitEthernet4
ip tftp blocksize 8192
ip route 0.0.0.0 0.0.0.0 9.6.0.1
ip route 202.153.144.25 255.255.255.255 9.6.0.1
!
!
!
tftp-server flash:/firmware/vadsl_module_img.bin
!
control-plane
!
!
line con 0
exec-timeout 0 0
line 4
no activation-character
transport preferred none
transport input all
transport output all
stopbits 1
line vty 0 4
login
transport input none
!
scheduler allocate 20000 1000
```

```
!
end
```

Verifying ADSL Configuration

Verify that the configuration is set properly by using the **show controller vdsl 0** command from the privileged EXEC mode.

```
Router# show controller vdsl 0
Controller VDSL 0 is UP

Daemon Status:           Up

                        XTU-R (DS)              XTU-C (US)
Chip Vendor ID:         'BDCM'                   'BDCM'
Chip Vendor Specific:   0x0000                   0xB11F
Chip Vendor Country:    0xB500                   0xB500
Modem Vendor ID:        'CSCO'                   'BDCM'
Modem Vendor Specific:  0x4602                   0x0000
Modem Vendor Country:   0xB500                   0xB500
Serial Number Near:    FCH2234TH6R C927-4P 15.8(3)M1
Serial Number Far:     eq_nr multiline_cpe software_rev
Modem Version Near:    15.8(3)M1
Modem Version Far:     0xb11f

Modem Status:          TC Sync (Showtime!)

DSL Config Mode:         AUTO
Trained Mode:   G.992.5 (ADSL2+) Annex A

TC Mode:                 ATM
Selftest Result:         0x00
DELT configuration:      disabled
DELT state:              not running
Link Status:             UP

Full inits:             26
Failed full inits:      15
Short inits:            8
Failed short inits:     3

Firmware        Source          File Name
--------        ------          ----------
VDSL            embedded        VDSL_LINUX_DEV_01212008

Modem FW  Version:      4.14L.04
Modem PHY Version:      A2pv6F039x8.d26d

Line:

                        XTU-R (DS)              XTU-C (US)
Trellis:                 ON                       ON
SRA:                     disabled                disabled
 SRA count:              0                       0
Bit swap:                enabled                 enabled
 Bit swap count:         0                       1
Line Attenuation:         1.0 dB                  2.4 dB
Signal Attenuation:       1.9 dB                  2.1 dB
Noise Margin:            10.8 dB                  7.3 dB
Attainable Rate:        27564 kbits/s           1283 kbits/s
Actual Power:            - 0.4 dBm              12.0 dBm
```

```
Total FECC:             0                       0
Total ES:               284                     77
Total SES:              150                     1
Total LOSS:             13                      0
Total UAS:              86969                   86840
Total LPRS:             0                       0
Total LOFS:             71                      0
Total LOLS:             0                       0


                  DS Channel1     DS Channel0   US Channel1       US Channel0
Speed (kbps):               0           27547             0              1279
SRA Previous Speed:         0               0             0                 0
Previous Speed:             0           27547             0              1279
Total Cells:                0        11338923             0            520053
User Cells:                 0               0             0                 0
Reed-Solomon EC:            0               0             0                 0
CRC Errors:                 0            5166             0               717
Header Errors:              0               0             0                 0
Interleave (ms):         0.00            0.07          0.00              0.49
Actual INP:              0.00            0.00          0.00              0.00

Training Log :  Stopped
Training Log Filename : flash:vdsllog.bin
```

Verifying CPE to Peer Connection for ADSL

Ping the peer to confirm that the CPE to peer configuration is set up correctly.

```
Router# ping 30.0.0.2 rep 20

Type escape sequence to abort.
Sending 20, 100-byte ICMP Echos to 30.0.0.2, timeout is 2 seconds:
!!!!!!!!!!!!!!!!!!!!
Success rate is 100 percent (20/20), round-trip min/avg/max = 20/22/28 ms
Router#
```

Configuring VDSL Mode

Perform the following tasks to configure VDSL mode:

- Configuring VDSL Auto Mode, page 85
- Configuring CPE and Peer for VDSL Mode, page 86
- Verifying VDSL Configuration, page 88
- Verifying CPE to Peer Connection for VDSL, page 89

Configuring VDSL Auto Mode

Note Configure the DSLAM in VDSL mode prior to configuring the router.

This example shows how to configure the VDSL controller to auto mode:

```
Router> enable
Router# configure terminal
```

```
Router(config)# controller vdsl 0
Router(config-controller)# operating mode auto
Router(config-controller)# end
Router#
```

Configuring CPE and Peer for VDSL Mode

When configuring VDSL, configure the ethernet 0 interface and perform a **no shutdown** command on the interface if needed.

Configuring the VDSL CPE Side

This example shows how to configure the VDSL CPE side:

```
Router> enable
Router# configure terminal
Router(config)# interface ethernet0
Router(config-if)# ip address 90.0.0.1 255.255.255.0
Router(config-if)# no shutdown
Router(config-if)# end
```

Configuring the VDSL Peer Side

This example shows how to configure the VDSL peer side:

```
Router> enable
Router# configure terminal
Router(config)# interface ethernet0
Router(config-if)# ip address 90.0.0.2 255.255.255.0
Router(config-if)# no shutdown
Router(config-if)# end
```

VDSL Configuration Example

This example shows a typical output of a VDSL configuration:

```
Router#show running
Building configuration...

Current configuration : 1456 bytes
!
! Last configuration change at 08:51:44 UTC Fri Jan 11 2019
!
version 15.8
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Router
!
boot-start-marker
boot system flash:c900-universalk9-mz.SPA.158-3.M1
boot-end-marker
!
!
!
no aaa new-model
```

```
!
!
!
!
!
!
!
!
!
!
!
!
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
license udi pid C927-4P sn FGL22511283
!
!
!
redundancy
!
!
controller VDSL 0
!
!
!
!
!
interface ATM0
 no ip address
 shutdown
 no atm ilmi-keepalive
!
interface ATM0.1 point-to-point
!
interface Ethernet0
 ip address 90.0.0.1 255.255.255.0
!
interface GigabitEthernet0
 no ip address
!
interface GigabitEthernet1
 no ip address
!
interface GigabitEthernet2
 no ip address
!
interface GigabitEthernet3
 no ip address
!
interface GigabitEthernet4
 ip address 9.6.9.29 255.255.0.0
 duplex auto
 speed auto
!
interface Vlan1
 no ip address
!
ip forward-protocol nd
```

```
no ip http server
no ip http secure-server
!
!
ip tftp source-interface GigabitEthernet4
ip tftp blocksize 8192
ip route 0.0.0.0 0.0.0.0 9.6.0.1
ip route 202.153.144.25 255.255.255.255 9.6.0.1
!
!
!
tftp-server flash:/firmware/vadsl_module_img.bin
!
control-plane
!
!
line con 0
exec-timeout 0 0
line 4
no activation-character
transport preferred none
transport input all
transport output all
stopbits 1
line vty 0 4
login
transport input none
!
scheduler allocate 20000 1000
!
end
```

Verifying VDSL Configuration

Verify the configuration is set properly by using the **show controller vdsl 0** command from privileged EXEC mode.

```
Router# show controller vdsl 0
Controller VDSL 0 is UP

Daemon Status:           Up

                        XTU-R (DS)              XTU-C (US)
Chip Vendor ID:         'BDCM'                   'BDCM'
Chip Vendor Specific:   0x0000                   0xB11F
Chip Vendor Country:    0xB500                   0xB500
Modem Vendor ID:        'CSCO'                   'BDCM'
Modem Vendor Specific:  0x4602                   0x0000
Modem Vendor Country:   0xB500                   0xB500
Serial Number Near:    FCH2234TH6R C927-4P 15.8(3)M1
Serial Number Far:     eq_nr multiline_cpe software_rev
Modem Version Near:    15.8(3)M1
Modem Version Far:     0xb11f

Modem Status:          TC Sync (Showtime!)

DSL Config Mode:         AUTO
Trained Mode:   G.993.2 (VDSL2) Profile 17a

TC Mode:                 PTM
Selftest Result:         0x00
DELT configuration:      disabled
```

```
DELT state:              not running
Link Status:             UP

Full inits:             28
Failed full inits:      15
Short inits:            8
Failed short inits:     7

Firmware        Source          File Name
--------        ------          ----------
VDSL            embedded        VDSL_LINUX_DEV_01212008

Modem FW  Version:      4.14L.04
Modem PHY Version:      A2pv6F039x8.d26d

Line:

                        XTU-R (DS)              XTU-C (US)
Trellis:                 ON                       ON
SRA:                     disabled                 disabled
 SRA count:              0                        0
Bit swap:                enabled                  enabled
 Bit swap count:         0                        0
Line Attenuation:         0.9 dB                   0.0 dB
Signal Attenuation:       1.8 dB                   0.0 dB
Noise Margin:            18.6 dB                  17.6 dB
Attainable Rate:        138139 kbits/s           87957 kbits/s
Actual Power:            14.1 dBm                 3.8 dBm
Per Band Status:        D1      D2      D3      U0      U1      U2      U3
Line Attenuation(dB):   0.2     0.9     1.7     N/A     0.0     0.0     0.0
Signal Attenuation(dB): 0.2     0.9     1.7     N/A     0.0     0.0     0.0
Noise Margin(dB):       27.7    16.9    10.9    N/A     15.5    16.3    21.3
Total FECC:             302690                   3
Total ES:               295                      77
Total SES:              161                      1
Total LOSS:             14                       0
Total UAS:              87189                    87049
Total LPRS:             0                        0
Total LOFS:             80                       0
Total LOLS:             0                        0


                  DS Channel1     DS Channel0   US Channel1       US Channel0
Speed (kbps):               0          128857             0             60013
SRA Previous Speed:         0               0             0                 0
Previous Speed:             0           27451             0              1288
Reed-Solomon EC:            0               0             0                 0
CRC Errors:                 0           24722             0                 1
Header Errors:              0               8             0                 0
Interleave (ms):        0.00            7.00          0.00              1.00
Actual INP:       0.00        1.00        0.00        0.10

Training Log :  Stopped
Training Log Filename : flash:vdsllog.bin
```

Verifying CPE to Peer Connection for VDSL

Ping the peer to confirm that CPE to peer configuration is setup correctly.

```
Router# ping 90.0.0.2 rep 20

Type escape sequence to abort.
```

```
Sending 20, 100-byte ICMP Echos to 90.0.0.2, timeout is 2 seconds:
!!!!!!!!!!!!!!!!!!!!
Success rate is 100 percent (20/20), round-trip min/avg/max = 20/22/28 ms
Router#
```

Configuring VLAN 0 Priority Tagging

The VLAN 0 Priority Tagging feature enables 802.1Q Ethernet frames to be transmitted with the VLAN ID set to zero. These frames are called priority tagged frames. Setting the VLAN ID tag to zero allows the VLAN ID tag to be ignored and the Ethernet frame to be processed according to the priority configured in the 802.1P bits of the 802.1Q Ethernet frame header.

This example shows how to configure VLAN Priority Tagging on the CPE side:

```
Router# configure terminal
Router(config)# interface GigabitEthernet0
Router(config-if)# encapsulation priority-tagged
Router(config-if)# ip address 2.2.2.1 255.255.255.0
Router(config-if)# end
```

This example shows how to configure VLAN Priority Tagging on the Peer side:

```
Router# configure terminal
Router(config)# interface GigabitEthernet0
Router(config-if)# encapsulation priority-tagged
Router(config-if)# ip address 2.2.2.2 255.255.255.0
Router(config-if)# end
```

Ping the peer to confirm that CPE to peer configuration is setup correctly. This example shows the ping output:

```
Router#ping 2.2.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
isr4221#sh run int gi0/0/0.1
Building configuration...

Current configuration : 105 bytes
!
interface GigabitEthernet0/0/0.1
 encapsulation priority-tagged
 ip address 2.2.2.2 255.255.255.0
end
```

Enabling ADSL2/2+ Annex M Mode on Over POTS VDSL2/ADSL Multimode Annex A SKUs

This example shows how to enable ADSL2/2+ Annex M mode on Over POTS VDSL2/ADSL Multimode Annex A SKUs:

```
Router> enable
Router# configure terminal
Router(config)# controller vdsl 0
Router(config-controller)# operating mode adsl2+ annex m
Router(config-controller)# end
```

```
Router#
```

Enabling Seamless Rate Adaption

This example shows how to enable SRA mode:

```
router# configure terminal
router(config)# controller vdsl 0
router(config-controller)# sra
router(config-controller)# end
router#
```

Note Use the **no** form of the command to disable SRA. SRA mode is disabled by default.

Configuring UBR+

This example shows how to configure UBR+ PVC on a DSL line:

```
Router> enable
Router# configure terminal
Router(config)# interface ATM 0/0
Router(config-if)# pvc 4/100
Router(config-if-atm-vc)# ubr+ 2304 2304
```

This example specifies the output-pcr argument for an ATM PVC to be 100000 kbps and the output-mcr to be 3000 kbps:

```
Router> enable
Router# configure terminal
Router(config)# interface ATM 0/0
Router(config-if)# pvc 1/32
Router(config-if-atm-vc)# ubr+ 100000 3000
```

This example specifies the output-pcr, output-mcr, input-pcr, and input-mcr arguments for an ATM SVC to be 10000 kbps, 3000 kbps, 9000 kbps, and 1000 kbps, respectively:

```
Router> enable
Router# configure terminal
Router(config)# interface ATM 0/0
Router(config-if)# svc lion nsap 47.0091.81.000000.0040.0B0A.2501.ABC1.3333.3333.05
Router(config-if-atm-vc)# ubr+ 10000 3000 9000 1000
```

Troubleshooting

Use the following show commands to troubleshoot DSL:

- **show interface Ethernet0**
- **show interface ATM0**
- **show interface summary**
- **show controller vdsl 0**
- **show controller vdsl 0 datapath**
- **show atm pvc**

Collecting DSL Training Logs

A training log provides you information about the different events that happened during the ADSL training.

This example shows how to start collecting the DSL training logs:

```
Router#debug vdsl 0 training log
Training log generation started for VDSL 0.
```

This example shows how to stop collecting the DSL training logs:

```
Router#no debug vdsl 0 training log
Training Log file for VDSL 0 written to flash:vdsllog.bin.
```

Training log also supports the auto-stop options. Use the following commands for auto-stop:

no debug vdsl 0 training log autostop linkdown: Stops the collection when the link goes down.
no debug vdsl 0 training log autostop linkup: Stops the collection when the link reaches the showtime.

By default, training log is stored in **flash:vdsllog.bin.**

You can modify the filename in which the training logs are stored before starting the training log collection. This example shows how to modify the filename:

```
Router#conf t
Router(config)#controller vdsl 0
Router(config-controller)#training log filename flash:mytraininglog.bin
Router(config-controller)#end
Router#sh controller vdsl 0 | sec Training Log
Training Log :Stopped
Training Log Filename :flash:mytraininglog.bin
Router#
```

Upgrading DSL Firmware

To upgrade the firmware on a DSL interface, perform these steps:

Step 1 Download the VDSL2 firmware from the Cisco Software Download Centre at https://software.cisco.com/download/home

Step 2 Copy the firmware to the router.

Step 3 Configure the router to load the new firmware from a designated location.

```
Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#controller vdsl 0
Router(config-controller)#firmware filename ?
  archive:   Download fw file name
  cns:       Download fw file name
  flash:     Download fw file name
  ftp:       Download fw file name
  http:      Download fw file name
  https:     Download fw file name
```

```
  null:      Download fw file name
  nvram:     Download fw file name
  pram:      Download fw file name
  rcp:       Download fw file name
  scp:       Download fw file name
  security:  Download fw file name
  system:    Download fw file name
  tar:       Download fw file name
  tftp:      Download fw file name
  tmpsys:    Download fw file name

Router(config-controller)#firmware filename flash:vdsl_fw.bin_39p1
```

Step 4 Restart the controller interface for the new firmware to take effect.

```
Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#controller vdsl 0
Router(config-controller)#shut
Router(config-controller)#no shut
Router(config-controller)#end
```

Configuring 4G Wireless WAN

This chapter provides information about configuring the 4G Wireless WAN interface on Cisco 900 Series ISRs and contains the following sections:

Overview of 4G LTE

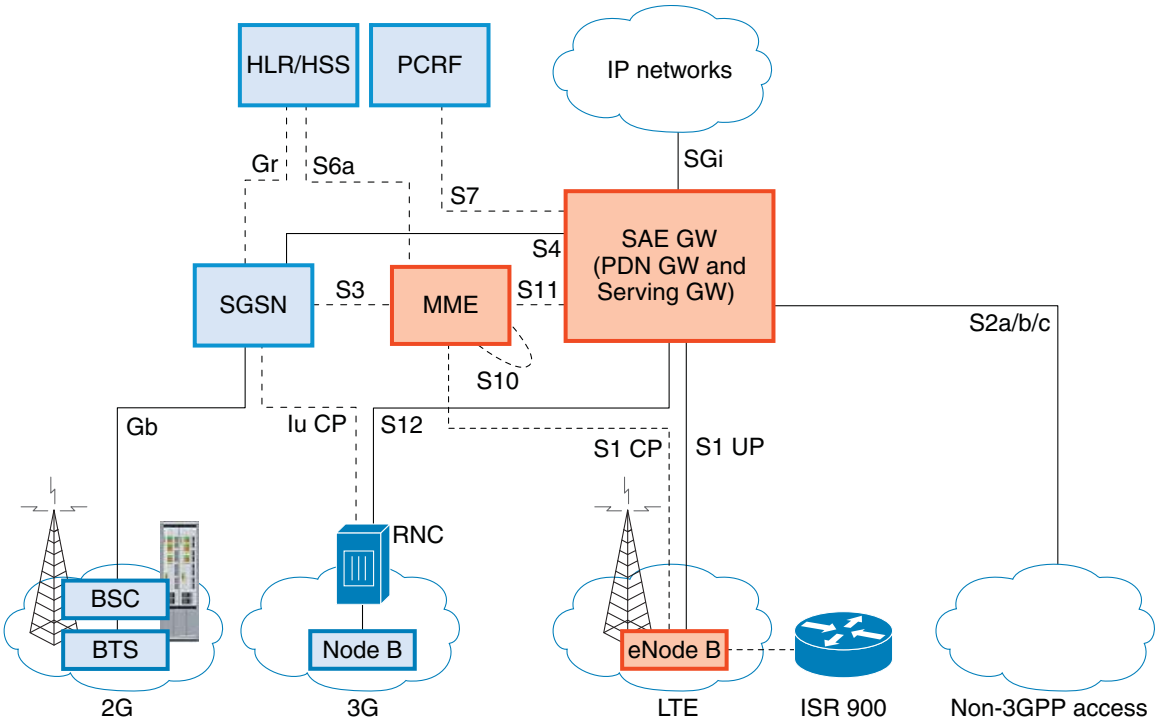
Cisco 900 series routers support Wireless WAN (WWAN). The WWAN SKUs operate over Fourth-Generation Long-Term Evolution (4G LTE) cellular networks and Third-Generation (3G) cellular networks. The Cisco 900 series routers offer a highly secure, simplified, and cost-effective WAN alternative to DSL or Frame Relay. In areas where terrestrial broadband services (cable, DSL, or T1) are not available or are expensive, 4G LTE WWAN connectivity can be a viable alternative.

Cisco 900 series routers support the following 4G/3G modes:

- **4G LTE**—4G LTE mobile specification provides multi-megabit bandwidth, more efficient radio network, latency reduction, and improved mobility. LTE solutions target new cellular networks. These networks initially support up to 97Mb/s peak rates in the downlink and up to 50 Mb/s peak rates in the uplink. The throughput of these networks is higher than the existing 3G networks
- **3G Evolution High-Speed Packet Access (HSPA/HSPA+)**—HSPA is a UMTS-based 3G network. It supports High-Speed Downlink Packet Access (HSDPA) and High-Speed Uplink Packet Access (HSUPA) data for improved download and upload speeds. Evolution High-Speed Packet Access (HSPA+) supports Multiple Input/Multiple Output (MIMO) antenna capability.

Figure 1 explains the 4G LTE packet core network architecture.

Figure 1 4G LTE Packet Core Network Architecture



Gateways	The Serving Gateway (SGW) routes and forwards user data packets, while also acting as the mobility anchor for the user plane, and is the anchor for mobility between LTE and other 3GPP technologies. The Packet Data Network (PDN) Gateway (PGW) provides connectivity from the User Equipment (UE) to external packet data networks by being the point of exit and entry of traffic for the UE. A UE may have simultaneous connectivity with more than one PGW for accessing multiple PDNs. The PGW performs policy enforcement, packet filtering for each user, charging support, lawful interception, and packet screening. Another key role of the PGW is to act as the anchor for mobility between 3GPP and non-3GPP technologies such as WiMAX and 3GPP2 (CDMA 1X and EvDO). The System Architecture Evolution GW (SAE GW) is the entity that covers the PGW and SGW functionality in the Evolved Packet Core (EPC).
RNC	The Radio Network Controller (RNC) is responsible for controlling the Radio Access Network (RAN) that are connected to it. The RNC carries out radio resource management and some of the mobility management functions and is the point where encryption is done before user data is sent to and from the mobile. The RNC connects to the Circuit-Switched Core Network through the Media Gateway (MGW).
MME	Mobility Management Entity.
SGW	Serving Gateway.
PCRF	Policy and Charging Rules Function
SAE	Service Architecture Evolution.
SGSN	Serving GPRS Support Node
HSS	Home Subscriber Server.

HLR	Home Location Register.
BTS	Base Transceiver Station.
BSC	Base Station Controller.
SGSN	Service GPRS Support Node.

Cisco 4G LTE Features

Cisco 4G LTE WWAN supports the following major features:

- 3G/4G Simple Network Management Protocol (SNMP) MIB
- Auto-switch failover between primary and backup link
- SIM lock and unlock capabilities
- PLMN Search
- Short Message Service (SMS)
- 3G backward compatible
- IPv4 and IPv6 addressing
- Auto SIM Firmware Switching
- Call History
- Cellular Backoff
- Modem reset, modem power cycle, radio on/off
- Modem crashdump collection
- Dialer
- DM Logging
- External Micro USB
- Firmware Upgrade
- Link Recovery
- Modem LED
- Multiple Profile
- PnP LTE WebUI Integration
- SIM OIR
- DMVPN
- CAT

The following features are not supported:

- Dying Gasp
- MEP
- Multiple PDN Context
- LTE Module OIR
- GPS and NMEA

- Dual SIM
- QoS
- NAS Message (SVB)
- Dual Modems
- 2K MTU
- Carrier Aggregation
- FOTA (Firmware Over-The-Air)
- CAT6

Prerequisites for Configuring Cisco 4G LTE

- You must have 4G LTE network coverage where your router is physically placed. For a complete list of supported carriers, see the product data sheet.
- You must subscribe to a service plan with a wireless service provider and obtain a Subscriber Identity Module (SIM) card.
- You must install the SIM card before configuring the 4G LTE Wireless WAN Module. For instructions on how to install the SIM card, see the Configuring a SIM for Data Calls, page 101 for more information.

Restrictions for Configuring Cisco 4G LTE

Follow these restrictions and usage guideline while configuring Cisco 4G LTE:

- Currently, cellular networks support only user initiated bearer establishment.
- Due to the shared nature of wireless communications, the experienced throughput varies depending on the number of active users or congestion in a given network.
- Cellular networks have higher latency compared to wired networks. Latency rates depend on the technology and carrier. Latency may be higher because of network congestion. Latency also depends on the signal conditions and can be higher because of network congestion.
- Any restrictions that are part of the terms of service from your carrier.
- For the router that runs the SNMP agent, you must configure appropriate access control (for example, SNMP-server community) using the Cisco IOS CLI for the NMS and agent to work properly.
- It is strongly recommended that you configure SNMP V3 with authentication/privacy when implementing SNMP SET operation.

How to Configure Cisco 4G LTE

This section explains how to configure 4G LTE on a Cisco 900 Series Router.

- Verifying Modem Signal Strength and Service Availability, page 99
- Creating, Modifying, or Deleting Modem Data Profiles, page 99

Verifying Modem Signal Strength and Service Availability

Use the following show commands to verify the modem signal strength and service availability:

- **show cellular** *unit* **network**
- **show cellular** *unit* **radio**
- **show cellular** *unit* **profile**
- **show cellular** *unit* **security**
- **show cellular** *unit* **all**

	Command or Action	Purpose
Step 1	**show cellular** *unit* **network** **Example:** `Router# show cellular 0 network`	Displays information about the carrier network, cell site, and available service.
Step 2	**show cellular** *unit* **radio** **Example:** `Router# show cellular 0 radio`	Shows the radio signal strength. **Note** The RSSI should be better than –90 dBm for steady and reliable connection.
Step 3	**show cellular** *unit* **profile** **Example:** `Router# show cellular 0 profile`	Shows information about the modem data profiles created.
Step 4	**show cellular** *unit* **security** **Example:** `Router# show cellular 0 security`	Shows the security information for the modem, such as SIM and modem lock status.
Step 5	**show cellular** *unit* **all** **Example:** `Router# show cellular 0 all`	Shows consolidated information about the modem, profiles created, radio signal strength, network security, and so on.

Creating, Modifying, or Deleting Modem Data Profiles

You can create multiple profiles on a 4G LTE SKU. The following are the default Internet profile numbers for some of the modems:

- WP7607—Profile 1

- WP7608—Profile 1
- WP7609—Profile 1 for attach and Profile 3 for data profile

Usage Guidelines for Creating, Modifying, or Deleting Data Profiles

Follow these guidelines while you configure a data profile:

- In most cases, you do not have to make any profile-related changes if your modem comes with a data profile.
- If any profile parameter changes are required for a connection type, the changes will most likely be carried out in the default profiles.
- To configure different profile types and use them for a different connection, you can create separate profiles with different parameters (for instance, APN names). Note that only one profile is active at a given time.
- Use the **cellular 0 lte profile create 1** ***APN-name*** **none ipv4v6** to create or modify profiles.
- Use the **cellular 0 lte profile delete 1** ***APN-name*** **none ipv4v6** or **cellular 0 lte profile delete 1** to delete a profile.
- Use the **show cellular <> profile** command to view the data profile. An asterisk(*) is displayed against the data profile.
- The data profile is used to set up a data call. If you want to use a different profile, that profile needs to be made the default one. Use the **lte sim data-profile** *number attach-profile number* command to change the default profile.

Configuration Examples

This example shows how to change a default profile:

```
router(config-controller)# lte sim data-profile 2 attach-profile 1
router(config-controller)# end
router#
router# sh run
Building configuration...
controller Cellular 0
 lte sim profile 2

router# ping 8.8.4.4 rep 10
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.192.187.254, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/69/106 ms
Viper-19#
```

This example shows the output of the **show cellular** command:

```
router# show cellular 0 profile
Profile 1 = ACTIVE* **
--------
PDP Type = IPv4v6
PDP address = 29.29.29.73
PDP IPV6 address = 2001:2678:2680:6E88:4DCC:F4F5:B936:C7EF/64 Scope: Global
Access Point Name (APN) = broadband
Authentication = None
Username:
Password:
Primary DNS address = 8.0.0.8
```

```
Secondary DNS address = 8.8.4.4
Primary DNS IPV6 address = 2006:4888:4888:0:0:0:0:8899
Secondary DNS IPV6 address = 2002:8888:9999:0:0:0:0:7722

* - Default profile
** - LTE attach profile
```

Configuring a SIM for Data Calls

Locking and Unlocking a SIM Card Using a PIN Code

Use the **cellular** *unit* **lte sim** {**lock** | **unlock**} *pin* command to lock or unlock a SIM card given by your service provider.

Caution The SIM card gets blocked if the wrong PIN is entered three consecutive times. Make sure you enter the correct PIN the SIM is configured with. If your SIM card gets blocked, contact your service provider for a PUK code. Using the PUK code, you can unblock the SIM card.

This example shows how to lock a SIM using the PIN code:

```
Router# cellular 0 lte sim lock 1111
```

Changing the PIN Code

Use the **cellular** *unit* **lte sim change-pin** *pin new-pin* command to change the PIN code of a SIM. This example shows how to change the PIN code:

```
Router# cellular 0 lte sim change-pin 1111 1234
```

Verifying the Security Information of a Modem

Use the **show cellular** *unit* **security** command to verify the security information of the modem. This example shows how to verify the security information:

```
Router# show cellular 0 security
```

Configuring Automatic Authentication for a Locked SIM

An unencrypted PIN can be configured to activate the Card Holder Verification (CHV1) code that authenticates a modem.

Caution The SIM card gets blocked if the wrong PIN is entered three consecutive times. Make sure you enter the correct PIN the SIM is configured with. If your SIM card gets blocked, contact your service provider for a PUK code.

Note Follow these procedures when using an unencrypted Level 0 PIN to configure CHV1. For instructions on how to configure CHV1 using an encrypted Level 7 PIN, see the Configuring an Encrypted PIN for a SIM, page 102.

Note A SIM should be locked for SIM authentication to work. To verify the SIM's status, use the **show cellular** *unit* **security** command.

This example shows how to configure an automatic authentication for a locked SIM:

```
Router# configure terminal
Router(config)# controller cellular 0
Router(config-controller)# lte sim authenticate 0 1111
```

Configuring an Encrypted PIN for a SIM

To configure an encrypted PIN, the scrambled value of the PIN must be obtained. This example shows how to get the scrambled Level 7 PIN and configure the SIM CHV1 code for verification using the encrypted PIN:

```
Router# configure terminal
Router(config)# service password-encryption
Router(config)# username SIM privilege 0 password 1111
Router(config)# do show run | i SIM
Router(config)# controller cellular 0
Router(config-controller)# lte sim authenticate 7 055A575E70
Router(config-controller)# exit
```

Note When obtaining the encrypted PIN for a SIM, a username and password are created by configuring password encryption, defining the username and associated password, copying the resulting scrambled password, and using this scrambled password in the SIM authentication command. After the scrambled PIN has been obtained and used in SIM authentication, the username created can be deleted from the Cisco IOS configuration.

Note A SIM should be locked for SIM authentication to work. To verify the SIM's status, use the **show cellular** *unit* **security** command.

Applying a Modem Profile in a SIM Configuration

This example shows how to apply a modem profile:

```
Router# configure terminal
Router(config)# controller cellular 0
Router(config-controller)# lte sim data-profile 2 attach-profile 2
```

For more information, see SIM Configuration: Examples, page 112

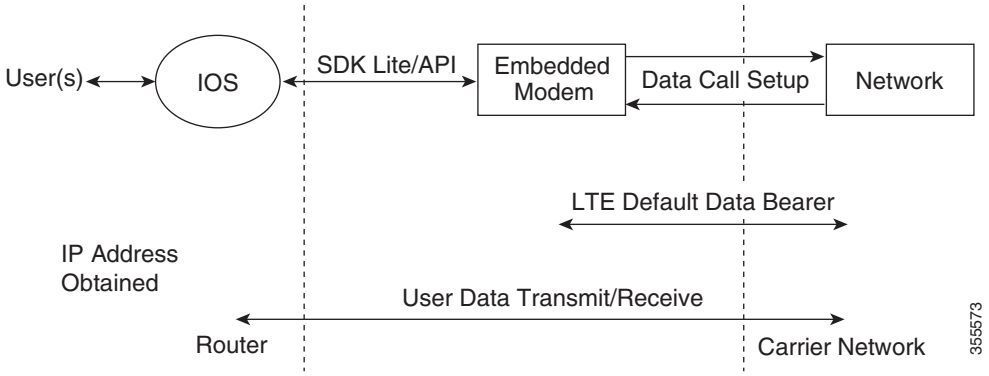
Data Call Setup

To set up a data call, use the following procedures:

- Configuring the Cellular Interface, page 103
- Configuring DDR, page 104
- Configuring DDR Backup, page 104

Figure 2 shows a typical data call setup.

Figure 2 Data Call Setup with WIM-LTE



Configuring the Cellular Interface

This example shows how to configure cellular interface:

```
Router# configure terminal
Router(config)# interface cellular 0
Router(config-if)# ip address negotiated
Router(config-if)# encapsulation slip
Router(config-if)# dialer in-band
Router(config-if)# dialer string lte
Router(config-if)# dialer-group 1
Router(config-if)# exit
Router(config)# chat-script lte"" "AT!CALL" TIMEOUT 60 "OK"
Router(config)# ip route 209.165.200.225 255.255.255.224 cellular 0
Router(config)# dialer-list 1 protocol ip list 1
Router(config)# line 3
Router(config-line)# script dialer lte
```

Configuring DDR

This example shows how to configure DDR:

```
Router# configure terminal
Router(config)# interface cellular 0
Router(config-if)# ip address negotiated
Router(config-if)# encapsulation slip
Router(config-if)# dialer in-band
Router(config-if)# dialer pool-member 1
Router(config-if)# interface dialer 1
Router(config-if)# ip address negotiated
Router(config-if)# encapsulation slip
Router(config-if)# dialer pool 1
Router(config-if)# dialer idle-timeout 30
Router(config-if)# dialer string lte
Router(config-if)# dialer-group 1
Router(config-if)# exit
Router(config)# dialer-list 1 protocol ip list 1
Router(config)# access-list 1 permit any
Router(config)# line 3
Router(config-line)# script dialer lte
Router(config-line)# exit
Router(config)# chat-script lte"" "AT!CALL" TIMEOUT 60 "OK"
```

Configuring DDR Backup

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

- Backup Interface—The backup interface that stays in standby mode until the primary interface line protocol is detected as down and then is brought up.
- Floating Static Route—The route through the backup interface has an administrative distance that is greater than the administrative distance of the primary connection route and therefore would not be in the routing table until the primary interface goes down.
- Dialer Watch—Dialer watch is a backup feature that integrates dial backup with routing capabilities.

Configuring Interfaces to Use a Backup Interface

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

This example shows how to configure an interface as a backup interface:

```
Router# configure terminal
Router(config)# interface atm 0
Router(config-if)# backup interface cellular 0
Router(config-if)# backup delay 0 10
```

AutoSim and Firmware Based Switching

The advantages of the AutoSim feature are:

- Ease of Ordering Carrier Specific SKUs
- Quicker failover times in dual-sim deployments

- Ease of switchover from other service providers to Telstra network

The modem in Auto-SIM mode selects the right carrier firmware after a SIM slot switch and an automatic modem reset. Auto-SIM is supported on the WP7607, WP7608, and WP7609 modems. During bootup, if the Auto-SIM configuration on the modem doesn't match the IOS configuration, the corresponding Auto-SIM or manual mode is pushed to the modem.

The modem automatically resets after an Auto-SIM configuration change.The default is 'auto-sim' enabled.

This example shows how to enable Auto-SIM:

```
router(config)#controller cellular <slot>
router(config-controller)#lte firmware auto-sim
```

Note After enabling auto-sim, wait for 5 minutes until the radio comes up. Once the radio is up, issue a modem power-cycle and wait for 3 minutes for the radio to come up again. Modem Power-Cycle is mandatory for auto-sim configuration to take effect.

This example shows how to disable Auto-SIM:

```
router(config)#controller cellular <slot>
router(config-controller)# no lte firmware auto-sim
```

Configuring 4G SMS Messaging

This example shows how to specify an FTP server folder path to send all the incoming and outgoing SMS messages. After the folder path is identified, it is appended automatically with outbox and inbox folders for the path to which SMS messages are sent and received:

```
Router# configure terminal
Router(config)# controller cellular 0
Router(config-controller)# lte sms archive path
ftp://username:password@172.25.211.175/SMS-LTE
Router# end
```

This example shows how to display the message contents of the incoming texts received by a modem:

```
Router# cellular 0 lte sms view summary

ID FROM YY/MM/DD HR:MN:SC SIZE CONTENT
0 4442235525 12/05/29 10:50:13 137 Your entry last month has...
2 5553337777 13/08/01 10:24:56 5 First
3 5553337777 13/08/01 10:25:02 6 Second
```

This example shows how to display all the information in the text messages sent and received. The message information includes text messages sent successfully, received, archived, and messages pending to be sent. The LTE-specific information on errors, in case of a FAILED attempt, may also be displayed:

```
Router# show cellular 0 sms
Incoming Message Information
----------------------------
SMS stored in modem = 20
SMS archived since booting up = 0
Total SMS deleted since booting up = 0
Storage records allocated = 25
Storage records used = 20
Number of callbacks triggered by SMS = 0
Number of successful archive since booting up = 0
```

```
Number of failed archive since booting up = 0

Outgoing Message Information
----------------------------
Total SMS sent successfully = 0
Total SMS send failure = 0
Number of outgoing SMS pending = 0
Number of successful archive since booting up = 0
Number of failed archive since booting up = 0
Last Outgoing SMS Status = SUCCESS
Copy-to-SIM Status = 0x0
Send-to-Network Status = 0x0
Report-Outgoing-Message-Number:
Reference Number = 0
Result Code = 0x0
Diag Code = 0x0 0x0 0x0 0x0 0x0

SMS Archive URL = ftp://lab:lab@1.3.150.1/outbox
```

This example shows how to enable a user to send a 4G LTE band SMS message to other valid recipients, provided they have a text message plan:

```
Router# cellular 0 lte sms send 15554443333 <sms text>
```

Upgrading Modem Firmware

To upgrade the modem firmware, perform these steps:

Step 1 Go to the Cisco Software Download website at: https://software.cisco.com/download/home

Step 2 On the download page, search '**900 series integrated services router**', and select '**900 integrated services router**' from the filtered list.

Step 3 Select **Routers> 900 Series Integrated Routers >900 Integrated Services Router**

Step 4 Select the release from the left pane. Available firmwares will be listed on the right pane.

Step 5 Select and download the appropriate firmware.

Step 6 Create a directory in the router flash to store the modem firmware.

Step 7 Copy the firmware to the flash directory.

Step 8 Use the following command to initiate the upgrade process:

```
Router# microcode reload cellular 0 lte modem-provision flash:firmware directory
```

Step 9 Verify the upgrade:

```
Router# show cellular 0 hardware

Modem Firmware Version = SWI9X07Y_02.18.05.00 000
Modem Firmware built = 2018/07/19 17:40:21
Device Model ID: WP7608
International Mobile Subscriber Identity (IMSI) = 123456000009205
International Mobile Equipment Identity (IMEI) = 354365090106005
Integrated Circuit Card ID (ICCID) = 8952530076180099205
Mobile Subscriber Integrated Services
Digital Network-Number (MSISDN) =
Factory Serial Number (FSN) = XG814285250410
Modem Status = Online
```

```
Current Modem Temperature = 42 deg C
PRI SKU ID = 1103787, PRI version = 002.041_002, Carrier = Generic
OEM PRI version = 001.004
```

Configuring Modem DM Log Collection

Diagnostic Monitor (DM) is a Qualcomm proprietary protocol. Diagnostic software tools, such as Sierra Wireless SwiLog and Qualcomm QXDM, are based on DM protocol. These tools can be used to capture data transactions between the modem and the network over the RF interface, which makes them useful tools for troubleshooting 3G and 4G data connectivity or performance issues.

This example shows how to enable DM log collection:

```
Router(config-controller)# lte modem dm-log enable
```

This example shows how to specify the maximum log file size:

```
Router(config-controller)# lte modem dm-log filesize 8
```

This example shows how to specify the filter file:

```
Router(config-controller)# lte modem dm-log filter flash:SwiLogPlus_generic_filter_6.3.sqf
```

This example shows how to specify the path where the DM log output files will be stored:

```
Router(config-controller)# lte modem dm-log output path ftp://@172.25.211.175/
```

This example shows how to enable DM log rotation:

```
Router(config-controller)# lte modem dm-log rotation
```

This example shows how to specify the maximum log size:

```
Router(config-controller)# lte modem dm-log size 128
```

For sample output, see Example: Sample Output for the show cellular logs modem-crashdump Command, page 117

Enabling Modem Crashdump Collection

Modem crashdump collection is useful in debugging firmware crash. To collect crash data, the modem has to be pre-configured so that it will stay in memdump mode after a crash. Memdump mode is a special boot-and-hold mode for the memdump utility to collect crash data.

To enable modem crashdump collection, perform the following steps.

Prerequisites

Ensure that the following prerequisites are met before attempting to enable crashdump logging:

- The modem needs to be provisioned for modem crashdump collection—it needs to be configured to operate in test mode. It also requires a debug bootloader installed. Contact Cisco TAC for details.

- The modem should be in crash state. Run tests that will result in modem firmware crash. A "MODEM_DOWN" message on the router console or syslog is indicative of modem firmware crash.

Note After the modem firmware crashes, the modem is available for crashdump log collection only. Data calls cannot be made.

This example shows how to pre-configure the modem to stay in memdump mode after a crash:

```
Router# configure terminal
Router(config)# controller cellular 0
Router(config-controller)#lte modem crash-action boot-and-hold
Router(config-controller)#end
```

This example shows how to disable crashdump log collection:

```
Router# configure terminal
Router(config)# service internal
Router(config)# end
Router(config)# test cell-host 0 modem-crashdump off
```

This example shows how to enable crashdump log collection with the logs stored on an FTP server:

```
Router# configure terminal
Router(config)# service internal
Router(config)# end
Router(config)# test cell-host 0 modem-crashdump on ftp://@172.25.211.175/
```

Displaying Modem Log Error and Dump Information

Use the following command to obtain the log error and dump information:

- **show cellular** *unit* **log error**

	Command or Action	Purpose
Step 1	**show cellular** *unit* **log error** **Example:** `Router# show cellular 0 log error`	Shows modem log error and dump information. For sample output, see Example: Sample Output for the show cellular log error Command, page 117

Configuration Examples for 4G LTE

Example: Basic Cellular Interface Configuration

This example shows how to configure the cellular interface to be used as a primary and is configured as the default route:

```
Router# show running-config
chat-script lte "" "AT!CALL" TIMEOUT 20 "OK"

interface Cellular0
ip address negotiated
encapsulation slip
dialer in-band
dialer string lte
dialer-group 1
async mode interactive

ip route 172.22.1.10 255.255.255.255 cellular 0

dialer-list 1 protocol ip permit

line 3
script dialer lte
modem InOut
```

Cellular Interface Configuration for Always-On Connection

This section provides the following configuration examples:

- Dialer-Watch Configuration without External Dialer Interface, page 109
- Dialer-Persistent Configuration with External Dialer Interface, page 110

Dialer-Watch Configuration without External Dialer Interface

This example shows how to configure dialer-watch without external dialer interface. The bold text is used to indicate important commands that are specific to dialer-watch.

```
chat-script lte "" "AT!CALL" TIMEOUT 20 "OK"

interface Cellular0
 ip address negotiated
 encapsulation slip
 dialer in-band
 dialer string LTE
 dialer watch-group 1
 async mode interactive
!
dialer watch-list 1 ip 5.6.7.8 0.0.0.0
dialer watch-list 1 delay route-check initial 60
dialer watch-list 1 delay connect 1
!
ip route 0.0.0.0 0.0.0.0 cellular 0
line 3
 script dialer LTE
 modem InOut
 no exec
 transport input all
 transport output all
```

Dialer-Persistent Configuration with External Dialer Interface

This example shows how to configure dialer-persistent with external dialer interface. The bold text is used to indicate important commands that are specific to dialer-persistent.

```
chat-script lte "" "AT!CALL" TIMEOUT 20 "OK"

interface Cellular0
 ip address negotiated
  encapsulation slip
 dialer in-band
 dialer pool-member 1
 async mode interactive
 routing dynamic

interface Dialer1
ip address negotiated
encapsulation slip
 dialer pool 1
 dialer idle-timeout 0
 dialer string lte
 dialer persistent
 dialer-group 1
!

dialer-list 1 protocol ip permit
ip route 0.0.0.0 0.0.0.0 dialer 1

line 3
 script dialer lte
 modem InOut
 no exec
 transport input all
 transport output all
```

4G-LTE Wireless WAN as Backup with NAT and IPSec

This example shows how to configure the 4G-LTE wireless WAN on the router as backup with NAT and IPSec:

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

```
ip dhcp excluded-address 10.4.0.254
!
ip dhcp pool lan-pool
   network 10.4.0.0 255.255.0.0
   dns-server 10.4.0.254
   default-router 10.4.0.254
!
!
chat-script lte "" "AT!CALL" TIMEOUT 20 "OK"

crypto isakmp policy 1
 encr 3des
 authentication pre-share
crypto isakmp key  address a.b.c.d
!
```

```
!
crypto ipsec transform-set  ah-sha-hmac esp-3des
!
crypto map gsm1 10 ipsec-isakmp
 set peer a.b.c.d
 set transform-set
 match address 103
!
!
interface ATM0
 no ip address
 ip virtual-reassembly
 load-interval 30
 no atm ilmi-keepalive
 dsl operating-mode auto
!
interface ATM0.1 point-to-point
 backup interface Cellular0
 ip nat outside
 ip virtual-reassembly
 no snmp trap link-status
 pvc 0/35
  pppoe-client dial-pool-number 2
 !
!
interface Cellular0
 ip address negotiated
 ip nat outside
 ip virtual-reassembly
 encapsulation slip
 no ip mroute-cache
 dialer in-band
 dialer idle-timeout 0
 dialer string lte
 dialer-group 1
 async mode interactive
 crypto map gsm1
!

interface Vlan104
 description used as default gateway address for DHCP clients
 ip address 10.4.0.254 255.255.0.0
 ip nat inside
 ip virtual-reassembly
!
interface Dialer2
 ip address negotiated
 ip mtu 1492
 ip nat outside
 ip virtual-reassembly
 encapsulation ppp
 load-interval 30
 dialer pool 2
 dialer-group 2
 ppp authentication chap callin
 ppp chap hostname cisco@dsl.com
 ppp chap password 0 cisco
 ppp ipcp dns request
 crypto map gsm1
!
ip local policy route-map track-primary-if
ip route 0.0.0.0 0.0.0.0 Dialer2 track 234
ip route 0.0.0.0 0.0.0.0 Cellular0/3/0 254
!
```

```
!
ip nat inside source route-map nat2cell interface Cellular0/3/0 overload
ip nat inside source route-map nat2dsl interface Dialer2 overload
!
ip sla 1
 icmp-echo 2.2.2.2 source-interface Dialer2
 timeout 1000
 frequency 2
ip sla schedule 1 life forever start-time now
access-list 1 permit any
access-list 101 deny ip 10.4.0.0 0.0.255.255 10.0.0.0 0.255.255.255
access-list 101 permit ip 10.4.0.0 0.0.255.255 any
access-list 102 permit icmp any host 2.2.2.2
access-list 103 permit ip 10.4.0.0 0.0.255.255 10.0.0.0 0.255.255.255
dialer-list 1 protocol ip list 1
dialer-list 2 protocol ip permit
!
!
route-map track-primary-if permit 10
 match ip address 102
 set interface Dialer2
!
route-map nat2dsl permit 10
 match ip address 101
 match interface Dialer2
!
route-map nat2cell permit 10
 match ip address 101
 match interface Cellular0/3/0
!
line 3
 exec-timeout 0 0
 script dialer lte
 login
 modem InOut
```

Note For service providers using a private IP address, use the **crypto ipsec transform-set esp** command (that is, esp-aes esp-sha256-hmac…).

SIM Configuration: Examples

Locking the SIM Card: Example

This example shows how to lock the SIM. The italicized text in this configuration example is used to indicate comments and are not be seen when a normal console output is viewed.

```
Router# show cellular 0 security
Card Holder Verification (CHV1) = Disabled
SIM Status = OK
```

```
SIM User Operation Required = None
Number of CHV1 Retries remaining = 3
Router#
!
!   SIM is in unlocked state.
!
Router# cellular 0 lte sim lock 1111
!!!WARNING: SIM will be locked with pin=1111(4).
Do not enter new PIN to lock SIM. Enter PIN that the SIM is configured with.
Call will be disconnected!!!
Are you sure you want to proceed?[confirm]
Router#
Apr 26 19:35:28.339: %CELLWAN-2-MODEM_DOWN: Modem in HWIC slot 0/0 is DOWN
Apr 26 19:35:59.967: %CELLWAN-2-MODEM_UP: Modem in HWIC slot 0/0 is now UP
Router#
Router# sh cellular 0 security
Card Holder Verification (CHV1) = Enabled
SIM Status = Locked
SIM User Operation Required = Enter CHV1
Number of CHV1 Retries remaining = 3
Router#
!
!   SIM is in locked state.
!
```

Unlocking the SIM Card: Example

This example shows how to unlock the SIM. The italicized text throughout this configuration example is used to indicate comments and will not be seen when a normal console output is viewed.

```
Router# show cellular 0 security
Card Holder Verification (CHV1) = Enabled
SIM Status = Locked
SIM User Operation Required = Enter CHV1
Number of CHV1 Retries remaining = 3
Router#
!
!   SIM is in locked state.
!

Router# cellular 0 lte sim unlock 1111
!!!WARNING: SIM will be unlocked with pin=1111(4).
Do not enter new PIN to unlock SIM. Enter PIN that the SIM is configured with.
Call will be disconnected!!!
Are you sure you want to proceed?[confirm]
Router#
Router# sh cellular 0 security
Card Holder Verification (CHV1) = Disabled
SIM Status = OK
SIM User Operation Required = None
Number of CHV1 Retries remaining = 3
Router#
!
!   SIM is in unlocked state.
!
```

Automatic SIM Authentication: Example

This example shows how to configure automatic SIM authentication. The italicized text throughout this configuration example is used to indicate comments and will not be seen when a normal console output is viewed.

```
Router# show cellular 0 security
Card Holder Verification (CHV1) = Disabled
SIM Status = OK
SIM User Operation Required = None
Number of CHV1 Retries remaining = 3
Router#
!
!   SIM is in unlocked state.
!
Router# cellular 0 lte sim lock 1111
!!!WARNING: SIM will be locked with pin=1111(4).
Do not enter new PIN to lock SIM. Enter PIN that the SIM is configured with.
Call will be disconnected!!!
Are you sure you want to proceed?[confirm]
Router#
Apr 26 21:22:34.555: %CELLWAN-2-MODEM_DOWN: Modem in HWIC slot 0/0 is DOWN
Apr 26 21:23:06.495: %CELLWAN-2-MODEM_UP: Modem in HWIC slot 0/0 is now UP
Router#
Router# sh cellular 0 security
Card Holder Verification (CHV1) = Enabled
SIM Status = Locked
SIM User Operation Required = Enter CHV1
Number of CHV1 Retries remaining = 3
Router#
!
!   SIM is in locked state. SIM needs to be in locked state for SIM authentication to
!   work.
!
Router#
Router# conf term
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# controller cellular 0
Router(config-controller)# lte sim authenticate 0 1111
CHV1 configured and sent to modem for verification
Router(config-controller)# end
Router#
Apr 26 21:23:50.571: %SYS-5-CONFIG_I: Configured from console by console
Router#
Router# sh cellular 0 security
Card Holder Verification (CHV1) = Enabled
SIM Status = OK
SIM User Operation Required = None
Number of CHV1 Retries remaining = 3
Router#
!
!   SIM is now in locked state but it can be used for connectivity since authentication is
!   good. Authentication can be saved in the router configuration so that when you boot up
!   the router with the same locked SIM, connection can be established with the correct
!   Cisco IOS configuration.
!
```

Changing the PIN Code: Example

This example shows how to change the assigned PIN code. The italicized text throughout this configuration example is used to indicate comments and will not be seen when a normal console output is viewed.

```
Router# show cellular 0 security
Card Holder Verification (CHV1) = Disabled
SIM Status = OK
SIM User Operation Required = None
Number of CHV1 Retries remaining = 3
```

```
Router#
!
!   SIM is in unlocked state.
!
Router#
Router# cellular 0 lte sim lock 1111
!!!WARNING: SIM will be locked with pin=1111(4).
Do not enter new PIN to lock SIM. Enter PIN that the SIM is configured with.
Call will be disconnected!!!
Are you sure you want to proceed?[confirm]
Router#
Apr 26 21:58:11.903: %CELLWAN-2-MODEM_DOWN: Modem in HWIC slot 0/0 is DOWN
Apr 26 21:58:43.775: %CELLWAN-2-MODEM_UP: Modem in HWIC slot 0/0 is now UP
Router#
Router# sh cellular 0 security
Card Holder Verification (CHV1) = Enabled
SIM Status = Locked
SIM User Operation Required = Enter CHV1
Number of CHV1 Retries remaining = 3
Router#
!
!   SIM is in locked state. SIM needs to be in locked state to change its PIN.
!
Router#
Router# cellular 0 lte sim change-pin 1111 0000
!!!WARNING: SIM PIN will be changed from:1111(4) to:0000(4)
Call will be disconnected. If old PIN is entered incorrectly in 3 attempt(s), SIM will be
blocked!!!
Are you sure you want to proceed?[confirm]
Resetting modem, please wait...

CHV1 code change has been completed. Please enter the new PIN in controller configuration
for verfication
Router#
Apr 26 21:59:16.735: %CELLWAN-2-MODEM_DOWN: Modem in HWIC slot 0/0 is DOWN
Apr 26 21:59:48.387: %CELLWAN-2-MODEM_UP: Modem in HWIC slot 0/0 is now UP
Router#
Router#
Router# sh cellular 0 security
Card Holder Verification (CHV1) = Enabled
SIM Status = Locked
SIM User Operation Required = Enter CHV1
Number of CHV1 Retries remaining = 3
Router#
!
!   SIM stays in locked state, as expected, but with new PIN.
!
Router# cellular 0 lte sim unlock 0000
!!!WARNING: SIM will be unlocked with pin=0000(4).
Do not enter new PIN to unlock SIM. Enter PIN that the SIM is configured with.
Call will be disconnected!!!
Are you sure you want to proceed?[confirm]
Router#
Router# show cellular 0 security
Card Holder Verification (CHV1) = Disabled
SIM Status = OK
SIM User Operation Required = None
Number of CHV1 Retries remaining = 3
Router#
!
!   Unlock with new PIN is successful. Hence, changing PIN was successful.
!
```

Configuring an Encrypted PIN: Example

This example shows how to configure automatic SIM authentication using an encrypted PIN. The italicized text throughout this configuration example is used to indicate comments and will not be seen when a normal console output is viewed.

```
Router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# service password-encryption
Router(config)# username SIM privilege 0 password 1111
Router(config)# do sh run | i SIM
username SIM privilege 0 password 7 055A575E70.
!
!   Copy the encrypted level 7 PIN. Use this scrambled PIN in the SIM authentication
!   command.
!
Router(config)#
Router(config)# controller cellular 0
Router(config-controller)# lte sim authenticate 7 055A575E70
CHV1 configured and sent to modem for verification
Router(config-controller)# exit
Router(config)# no username SIM
Router(config)# end
May 14 20:20:52.603: %SYS-5-CONFIG_I: Configured from console by console
```

Configuration Examples for 4G Serviceability Enhancement

This section contains the following subsections:

Example: Sample Output for the show cellular logs dm-log Command

This example shows a sample output of the **show cellular logs dm-log** command:

```
Router# show cellular 0 logs dm-log
Integrated DM logging is on
output path = flash:
filter = MC74xx generic - GSM_GPRS_EDGE_WCDMA_LTE_EVDO.sqf
maximum log size = 67108864
maximum file size = 20971520
log rotation = disabled

33 packets sent to the modem, 4663 bytes, 0 errors
262 packets received from the modem, 374428 bytes, 0 input drops
262 packets stored in file system, 374428 bytes, 0 errors, 0 aborts
1 max rcv queue size

current file size = 374428
current log size = 374428
total log size = 374428
DM log files: (1 files)
flash:dmlog19560707-032507.bin size 374428
```

Example: Sample Output for the show cellular logs modem-crashdump Command

This example shows a sample output of the **show cellular logs modem-crashdump** command:

```
Router# show cellular 0 logs modem-crashdump
Modem crashdump logging: off
Progress = 100%
Last known State = Getting memory chunks
Total consecutive NAKs = 0
Number of retries = 0
Memory Region Info:
1: Full SDRAM [Base:0x0, Length:0x2000000]
2: MDSP RAM A region [Base:0x91000000, Length:0x8000]
3: MDSP RAM B region [Base:0x91200000, Length:0x8000]
4: MDSP RAM C region [Base:0x91400000, Length:0xC000]
5: MDSP Register region [Base:0x91C00000, Length:0x28]
6: ADSP RAM A region [Base:0x70000000, Length:0x10000]
7: ADSP RAM B region [Base:0x70200000, Length:0x10000]
8: ADSP RAM C region [Base:0x70400000, Length:0xC000]
9: ADSP RAM I region [Base:0x70800000, Length:0x18000]
10: CMM Script [Base:0x6A350, Length:0x310]
Router#
```

Example: Sample Output for the show cellular log error Command

This example shows a sample output of the **show cellular log error** command:

```
Router# show cellular 0 log error
 Cached info is displayed

at!err

00   4E hsu_conf_sel_nv  00536
01   9B uim              08280
02   FF rrcllcpcie       15762
03   FF rrccspfscan      02169
04   4E dsatact          00696
05   4E dsatcmdp         01841
06   4D gsdi_convert     01526
07   04 rrccsputil       18579
08   02 cmss             03459
09   2D tmc              03825


OK

at!gcdump

No crash data available

OK
```

Example: Sample Output for the test cellular modem-error-clear Command

This example shows a sample output of the **test cellular modem-error-clear** command:

```
Router# test cellular 0 modem-error-clear
Cellular0/1/0 Dump/Error info before clear command

at!err

00   4E hsu_conf_sel_nv  00536
```

```
01   9C uim              08280
02   FF rrcllcpcie       15762
03   FF rrccspfscan      02169
04   4E dsatact          00696
05   4E dsatcmdp         01841
06   4E gsdi_convert     01526
07   04 rrccsputil       18579
08   02 cmss             03459
09   2D tmc              03825

OK

at!gcdump

No crash data available

OK

Cellular0/1/0 Dump/Error registers cleared

Router#
```

PLMN Search and Selection

This feature allows you to search for available Public Land Mobile Network (PLMN) and connect to one of the PLMN.

Restrictions

This restrictions apply for PLMN search and selection:

- Support in Cisco LTE 2.0 and WP76XX modem series and above.
- You have to verify whether your cellular service supports roaming or not.
- You have to use a SIM card that supports roaming.
- This feature is not supported on 4G+WiFi platforms.
- Supported firmware version is 02.18.05.00 or later.

Commands

Use the following commands for PLMN feature:

- **cellular <*unit*> lte plmn search**
- **cellular <*unit*> lte plmn select <*mode*> <*mcc*> <*mnc*> <*rat*> <*duration*>**
- **show cellular <*unit*> network**

Searching the Network

You can use the **cellular 0 lte plmn search** command to search for available PLMNs. This example shows how to search for networks:

```
router#cellular 0 lte plmn search
Searching for available PLMNs.This may take up to 3 minutes.
```

```
Please wait.........................
PLMN search done. Please use "show cellular 0 network" to see available PLMNS
```

After the search, use the **show cellular 0 network** command to see the available networks:

```
router#show cellular 0 network
Current System Time = Fri Sep 18 18:49:24 2015
Current Service Status = Normal
Current Service = Packet switched
Current Roaming Status = Roaming
Network Selection Mode = Manual
Network = O2 - UK
Mobile Country Code (MCC) = 234
Mobile Network Code (MNC) = 10
Packet switch domain(PS) state = Attached
Location Area Code (LAC) = 4931
Cell ID = 34319
Available PLMNs:
Idx MCC MNC RAT     Desc
1   234 10  umts    O2 - UK
2   234 10  gsm     O2 - UK
3   234 20  umts    3 UK
4   234 30  umts    EE
5   234 15  gsm     voda UK
6   234 33  gsm     EE
7   234 20  lte     3 UK
8   234 30  gsm     EE
9   234 15  umts    voda UK
10  234 30  lte     EE
11  234 10  lte     O2 - UK
12  234 15  lte     voda UK
```

Selecting the Network

There are three ways you can select an available network: Auto mode, Force Mode, and Manual mode. In Auto mode, your router will connect automatically to a network preferred by the SIM. In Force mode, the router is forced to select an available or known network without performing a network search. If a network is not available or the router is unable to attach to a network, then the router will remain in a 'Not attached' state. You can use the **cellular x lte plmn select auto** command to attach the router to a network preferred by the SIM. In Manual mode, you can select an available network from your search result.

This example shows how to select a network manually:

```
router#cellular 0 lte plmn select manual ?
  <0-999>  Mobile Country Code (MCC)

router#cellular 0 lte plmn select manual 234 ?
  <0-999>  Mobile Network Code (MNC)

router#cellular 0 lte plmn select manual 234 10 ?
  gsm   GSM
  lte   LTE
  umts  UMTS

router#cellular 0 lte plmn select manual 234 10 gsm ?
  permanent    PERMANENT
  power-cycle  POWER_CYCLE

router#cellular 0 lte plmn select manual 234 10 gsm power-cycle ?

  <cr>
```

```
router#cellular 0 lte plmn select manual 234 10 gsm power-cycle
```

This example shows how to force a network selection:

```
router#cellular 0 lte plmn select force ?
  <0-999>  Mobile Country Code (MCC)

router#cellular 0 lte plmn select force 310 ?
  <0-999>  Mobile Network Code (MNC)

router#cellular 0 lte plmn select force 310 410 ?
  <2-3>  MNC Digits Ex 23 means 2 Digits, 023 Means 3 Digits

router#cellular 0 lte plmn select force 310 410 2 ?
  gsm   GSM
  lte   LTE
  umts  UMTS

router#cellular 0 lte plmn select force 310 410 2 lte ?
  permanent    PERMANENT
  power-cycle  POWER_CYCLE

Router#cellular 0 lte plmn select force 310 410 2 lte power-cycle ?
  <cr>

Router#cellular 0 lte plmn select force 310 410 2 lte power-cycle
```

Verifying PLMN Selection

Use **show cellular 0 network** command to verify the PLMN selection:

```
router#show cellular 0 network
Current System Time = Fri Sep 18 18:53:25 2015
Current Service Status = Normal
Current Service = Packet switched
Current Roaming Status = Roaming
Network Selection Mode = Manual
Network = O2 - UK
Mobile Country Code (MCC) = 234
Mobile Network Code (MNC) = 10
Packet switch domain(PS) state = Attached
Location Area Code (LAC) = 4931
Cell ID = 34319
Available PLMNs:
Idx MCC MNC RAT     Desc
1   234 10  umts    O2 - UK
2   234 10  gsm     O2 - UK
3   234 20  umts    3 UK
4   234 30  umts    EE
5   234 15  gsm     voda UK
6   234 33  gsm     EE
7   234 20  lte     3 UK
8   234 30  gsm     EE
9   234 15  umts    voda UK
10  234 30  lte     EE
11  234 10  lte     O2 - UK
12  234 15  lte     voda UK

router#show cellular 0 radio
Radio power mode = ON
Channel Number = 122
```

```
Current Band = GSM 900 Extended
Current RSSI = -48 dBm
Current ECIO = -127 dBm
Radio Access Technology(RAT) Preference = GSM
Radio Access Technology(RAT) Selected = EDGE
```

Note Some networks may not allow the router to connect. In such cases, you have to choose a different network.

Note Restart your modem if the router is not able to connect to any network.

SNMP MIBs

The following Simple Management Network Protocol (SNMP) MIBs are supported on Cisco 4G LTE Module:

- IF-MIB
- ENTITY-MIB
- CISCO-WAN-3G-MIB

For the CISCO-WAN-3G-MIB, the following tables and sub-tables are supported for 3G and LTE technologies:

- ciscoWan3gMIB(661)
- ciscoWan3gMIBNotifs(0)
- ciscoWan3gMIBObjects(1)
- c3gWanCommonTable(1)
- c3gWanGsm(3)
- c3gGsmIdentityTable(1)
- c3gGsmNetworkTable(2)
- c3gGsmPdpProfile(3)
- c3gGsmPdpProfileTable(1)
- c3gGsmPacketSessionTable(2)
- c3gGsmRadio(4)
- c3gGsmRadioTable(1)
- c3gGsmSecurity(5)
- c3gGsmSecurityTable(1)

You can download the MIBs from the Cisco MIB Locator at http://www.cisco.com/go/mibs.

SNMP 4G LTE Configuration: Example

This example describes how to configure SNMP capability on the router:

```
snmp-server group neomobilityTeam v3 auth notify 3gView
snmp-server view 3gView ciscoWan3gMIB included
```

```
snmp-server community neomobility-test RW
snmp-server community public RW
snmp-server enable traps c3g
snmp-server host 172.19.153.53 neomobility  c3g
snmp-server host 172.19.152.77 public  c3g
snmp-server host 172.19.152.77 public udp-port 6059
```

This example describes how to configure an external host device to communicate with the router through SNMP:

```
setenv SR_MGR_CONF_DIR /users/<userid>/mibtest
setenv SR_UTIL_COMMUNITY neomobility-test
setenv SR_UTIL_SNMP_VERSION -v2c
setenv SR_TRAP_TEST_PORT 6059
```

Troubleshooting

This section provides the necessary background information and resources available for troubleshooting the Cisco 4G-LTE Wireless module.

Verifying Data Call Setup

To verify the data call setup, follow these steps:

Step 1 After you create a modem data profile using the **cellular profile create** command and configuring DDR on the cellular interface, send a ping from the router to a host across the wireless network.

Step 2 If the ping fails, debug the failure by using the following **debug** and **show** commands:

- **debug chat**
- **debug modem**
- **debug dialer**
- **show cellular all**
- **show interface cellular**
- **show running-config**
- **show ip route**

Step 3 Save the output from these commands and contact your system administrator.

Checking Signal Strength

If the Received Signal Strength Indication (RSSI) level is very low (for example, if it is less than –110 dBm), follow these steps:

Step 1 Check the antenna connection. Make sure the SMA connector is correctly threaded and tightened.

Step 2 If you are using a remote antenna, move the antenna cradle and check if the RSSI has improved.

Step 3 Contact your wireless service provider to verify if there is service availability in your area.

Verifying Service Availability

This example shows a sample output for the **show cellular all** command for a scenario where the antenna is disconnected and a modem data profile has not been created. The errors in this case have been highlighted with >>>>>>>.

```
Router# show cellular 0 all

Hardware Information
====================
Modem Firmware Version = SWI9600M_01.00.09.03
Modem Firmware built = 2011/07/01 19:31:09
Hardware Version = 20460000
International Mobile Subscriber Identity (IMSI) = <specific sim number>
International Mobile Equipment Identity (IMEI) = <specific modem number>
Electronic Serial Number (ESN) = <specific ESN in Hex> [specific ESN in Dec]
Integrated Circuit Card ID (ICCID) = <specific ICCID number>
Mobile Subscriber International Subscriber
IDentity Number (MSISDN) = <specific phone number>


Profile Information
====================
 * - Default profile >>>>>>>> no profile here.

Data Connection Information
============================

Profile 1, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 2, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 3, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 4, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 5, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 6, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 7, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 8, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 9, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 10, Packet Session Status = INACTIVE
```

```
        Inactivity Reason = Normal inactivate state
Profile 11, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 12, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 13, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 14, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 15, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state
Profile 16, Packet Session Status = INACTIVE
        Inactivity Reason = Normal inactivate state



Network Information
===================
Current Service Status = No service, Service Error = None    >>>>>>> no service means not
connected to the network.
Current Service = Packet Switched
Current Roaming Status = Home
Network Selection Mode = Automatic
Country = , Network =
Mobile Country Code (MCC) = 0
Mobile Network Code (MNC) = 0


Radio Information
=================
Radio power mode = Online
Current RSSI = -125 dBm        >>>>>>> either no antenna, or bad antenna or out of
network.
Radio power mode = Online
LTE Technology Selected = LTE

Modem Security Information
==========================
Card Holder Verification (CHV1) = Disabled
SIM Status = OK
SIM User Operation Required = None
Number of CHV1 Retries remaining = 3
```

Successful Call Setup

This example shows a sample output when a call is set up using a chat script. It shows a received IP address from the network. Call setup is successful and data path is open.

```
debug modem
debug chat

Router#
Aug 25 18:46:59.604: CHAT0: Attempting async line dialer script
Aug 25 18:46:59.604: CHAT0: Dialing using Modem script: lte & System script: none
Aug 25 18:46:59.604: CHAT0: process started
Aug 25 18:46:59.604: CHAT0: Asserting DTR
Aug 25 18:46:59.604: CHAT0: Chat script lte started
Aug 25 18:46:59.604: CHAT0: Sending string: AT!CALL
Aug 25 18:46:59.604: CHAT0: Expecting string: OK
```

```
Aug 25 18:47:00.641: CHAT0: Completed match for expect: OK
Aug 25 18:47:00.641: CHAT0: Chat script lte finished, status = Success
Aug 25 18:47:00.641: TTY0: no timer type 1 to destroy
Aug 25 18:47:00.641: TTY0: no timer type 0 to destroy
Aug 25 18:47:00.641: TTY0: no timer type 2 to destroy
Aug 25 18:47:02.642: %LINK-3-UPDOWN: Interface Cellular0, changed state to up
Aug 25 18:47:02.642: %DIALER-6-BIND: Interface Ce0 bound to profile Di1
Aug 25 18:47:03.642: %LINEPROTO-5-UPDOWN: Line protocol on Interface Cellular0, changed
state to up (69.78.96.14) [OK]
```

Configuring Secure Storage

Secure Storage feature allows you to secure critical configuration information by encrypting it. It encrypts VPN, IPSec, and other asymmetric key-pairs, pre-shared secrets, the type 6 password encryption key and certain credentials. An instance-unique encryption key is stored in the hardware trust anchor to prevent it from being compromised.

By default, this feature is enabled on platforms that come with a hardware trust anchor. This feature is not supported on platforms that do not have hardware trust anchor.

Enabling Secure Storage

The following example shows how to enable Secure Storage:

```
router#config terminal
router(config)# service private-config-encryption
router(config)# do write memory
```

Note By default, this feature is enabled on a platform. Use the above procedure on a platform where it is disabled.

Disabling Secure Storage

The following example shows how to disable Secure Storage:

```
router#config terminal
router(config)# no service private-config-encryption
router(config)# do write memory
```

Verifying the Status of Encryption

Use the **show parser encrypt file status** command to verify the status of encryption. The following command output indicates that the feature is available but the file is not encrypted. The file is in "plain text" format.

```
router#show parser encrypt file status
Feature: Enabled
File Format: Plain Text
Encryption Version: Ver1
```

The following command output indicates that the feature is enabled and the file is encrypted. The file is in "cipher text" format.

```
router#show parser encrypt file status
Feature: Enabled
File Format: Cipher Text
Encryption Version: Ver1
```

Verifying the Platform Identity

Use the **show platform sudi certificate** command to display the SUDI certificate in standard PEM format. The command output helps you verify the platform identity.

In the command output, the first certificate is the Cisco Root CA 2048 and the second is the Cisco subordinate CA (ACT2 SUDI CA). The third is the SUDI certificate.

```
router#show platform sudi certificate sign nonce 123
-----BEGIN CERTIFICATE-----
MIIDQzCCAiugAwIBAgIQX/h7KCtU3I1CoxW1aMmt/zANBgkqhkiG9w0BAQUFADA1
MRYwFAYDVQQKEw1DaXNjbyBTeXN0ZW1zMRswGQYDVQQDExJDaXNjbyBSb290IENB
IDIwNDgwHhcNMDQwNTE0MjAxNzEyWhcNMjkwNTE0MjAyNTQyWjA1MRYwFAYDVQQK
Ew1DaXNjbyBTeXN0ZW1zMRswGQYDVQQDExJDaXNjbyBSb290IENBIDIwNDgwggEg
MA0GCSqGSIb3DQEBAQUAA4IBDQAwggEIAoIBAQCwmrmrp68Kd6ficba0ZmKUeIhH
xmJVhEAyv8CrLqUccda8bnuoqrpu0hWISEWdovyD0My5jOAmaHBKeN8hF570YQXJ
FcjPFto1YYmUQ6iEqDGYeJu5Tm8sUxJszR2tKyS7McQr/4NEb7Y9JHcJ6r8qqB9q
VvYgDxFUl4F1pyXOWWqCZe+36ufijXWLbvLdT6ZeYpzPEApk0E5tzivMW/VgpSdH
jWn0f84bcN5wGyDWbs2mAag8EtKpP6BrXruOIIt6keO1aO6g58QBdKhTCytKmg9l
Eg6CTY5j/e/rmxrbU6YTYK/CfdfHbBcl1HP7R2RQgYCUTOG/rksc35LtLgXfAgED
o1EwTzALBgNVHQ8EBAMCAYYwDwYDVR0TAQH/BAUwAwEB/zAdBgNVHQ4EFgQUJ/PI
FR5umgIJFq0roIlgX9p7L6owEAYJKwYBBAGCNxUBBAMCAQAwDQYJKoZIhvcNAQEF
BQADggEBAJ2dhISjQal8dwy3U8pORFBi71R803UXHOjgxkhLtv5MOhmBVrBW7hmW
Yqpao2TB9k5UM8Z3/sUcuuVdJcr18JOagxEu5sv4dEX+5wW4q+ffy0vhN4TauYuX
cB7w4ovXsNgOnbFp1iqRe6lJT37mjpXYgyc81WhJDtSd9i7rp77rMKSsH0T81lasz
Bvt9YAretIpjsJyp8qS5UwGH0GikJ3+r/+n6yUA4iGe0OcaEb1fJU9u6ju7AQ7L4
CYNu/2bPPu8Xs1gYJQk0XuPL1hS27PKSb3TkL4Eq1ZKR4OCXPDJoBYVL0fdX41Id
kxpUnwVwwEpxYB5DC2Ae/qPOgRnhCzU=
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
MIIEPDCCAySgAwIBAgIKYQlufQAAAAAADDANBgkqhkiG9w0BAQUFADA1MRYwFAYD
VQQKEw1DaXNjbyBTeXN0ZW1zMRswGQYDVQQDExJDaXNjbyBSb290IENBIDIwNDgw
HhcNMTEwNjMwMTc1NjU3WhcNMjkwNTE0MjAyNTQyWjAnMQ4wDAYDVQQKEwVDaXNj
bzEVMBMGA1UEAxMMQUNUMiBTVURJIENBMIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8A
MIIBCgKCAQEA0m5l3THIxA9tN/hS5qR/6UZRpdd+9aE2JbFkNjht6gfHKd477AkS
5XAtUs5oxDYVt/zEbslZq3+LR6qrqKKQVu6JYvH05UYLBqCj38s76NLk53905Wzp
9pRcmRCPuX+a6tHF/qRuOiJ44mdeDYZo3qPCpxzprWJDPclM4iYKHumMQMqmgmg+
xghHIooWS80BOcdiynEbeP5rZ7qRuewKMpl1TiI3WdBNjZjnpfjg66F+P4SaDkGb
BXdGj13oVeF+EyFWLrFjj97fL2+8oauV43Qrvnf3d/GfqXj7ew+z/sXlXtEOjSXJ
URsyMEj53Rdd9tJwHky8neapszS+r+kdVQIDAQABo4IBWjCCAVYwCwYDVR0PBAQD
```

```
AgHGMB0GA1UdDgQWBBRI2PHxwnDVW7t8cwmTr7i4MAP4fzAfBgNVHSMEGDAWgBQn
88gVHm6aAgkWrSugiWBf2nsvqjBDBgNVHR8EPDA6MDigNqA0hjJodHRwOi8vd3d3
LmNpc2NvLmNvbS9zZWN1cml0eS9wa2kvY3JsL2NyY2EyMDQ4LmNybDBQBggrBgEF
BQcBAQREMEIwQAYIKwYBBQUHMAKGNGh0dHA6Ly93d3cuY2lzY28uY29tL3NlY3Vy
aXR5L3BraS9jZXJ0cy9jcmNhMjA0OC5jZXIwXAYDVR0gBFUwUzBRBgorBgEEAQkV
AQwAMEMwQQYIKwYBBQUHAgEWNWh0dHA6Ly93d3cuY2lzY28uY29tL3NlY3VyaXR5
L3BraS9wb2xpY2llcy9pbmRleC5odG1sMBIGA1UdEwEB/wQIMAYBAf8CAQAwDQYJ
KoZIhvcNAQEFBQADggEBAGh1qclr9tx4hzWgDERm371yeuEmqcIfi9b9+GbMSJbi
ZHc/CcCl0lJu0a9zTXA9w47H9/t6leduGxb4WeLxcwCiUgvFtCa51Iklt8nNbcKY
/4dw1ex+7amATUQO4QggIE67wVIPu6bgAE3Ja/nRS3xKYSnj8H5TehimBSv6TECi
i5jUhOWryAK4dVo8hCjkjEkzu3ufBTJapnv89g9OE+H3VKM4L+/KdkUO+52djFKn
hyl47d7cZR4DY4LIuFM2P1As8YyjzoNpK/urSRI14WdIlplR1nH7KNDl5618yfVP
0IFJZBGrooCRBjOSwFv8cpWCbmWdPaCQT2nwIjTfY8c=
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
 MIIDhzCCAm+gAwIBAgIEAJT3DDANBgkqhkiG9w0BAQsFADAnMQ4wDAYDVQQKEwVD
aXNjbzEVMBMGA1UEAxMMQUNUMiBTVURJIENBMB4XDTE1MTExNDA5MzMzN1oXDTI1
MTExNDA5MzMzN1owczEsMCoGA1UEBRMjUElEOldTLUMzNjUwLTEyWDQ4VVEgU046
RkRPMTk0NkJHMDUxDjAMBgNVBAoTBUNpc2NvMRgwFgYDVQQLEw9BQ1QtMiBMaXRl
IFNVREkxGTAXBgNVBAMTEFdTLUMzNjUwLTEyWDQ4VVEwggEiMA0GCSqGSIb3DQEB
AQUAA4IBDwAwggEKAoIBAQC6SARWyImWrRV/x7XQogAE+02WmzKki+4arMVBvl9o
GgvJfkoJDdaHOROSUkEE3qXtd8N3lfKy3TZ+jtHD85m2aGz6+IRx/e/lLsQzi6dl
WIB+N94pgecFBONPR9wJriox1IGD3B43b0hMLkmro4R5Zrs8XFkDo9k1tBU7F2O7
GEzb/WkO5NLexznef2Niglx9fCDL0HC27BbsR5+03p8jhG0+mvrp8M9du1HKiGin
ZIV4XgTMp1/k/TVaIepEGZuWM3hxdUZjkNGG1c1m+oB8vLX3UlSL76sDBBoiaprD
rjXBgBIozyFW8tTjh50jMDG84hKD5s31ifOe4KpqEcnVAgMBAAGjbzBtMA4GA1Ud
DwEB/wQEAwIF4DAMBgNVHRMBAf8EAjAAME0GA1UdEQRGMESgQgYJKwYBBAEJFQID
oDUTM0NoaXBJRD1VWUpOTlZJMENBUkhVM1Z1SUVSbFl5QXlPQ0F4TXpvek5Ub3lN
U0EwS0NnPTANBgkqhkiG9w0BAQsFAAOCAQEADjtM8vdlf+p1WKSKX1C1qQ4aEnD5
p8T5e4iTer7Y1fbCrHIEEm3mnip+568j299z0H8V7PDp1ljuLHyMFTC+945F9RfA
eAuVWVb5A9dnGL8MssBJe2lVSnZwrWkT1EIdxLYrTiPAQHtll6CN77S4u/f71oYE
tzPE5AGfyGw7ro1MEPVGffaQmYUDAwKFNBH1uI7c2S1qlwk4WWZ6xxci+lhaQnIG
pWzapaiAYL1XrcBz4KwFc1ZZpQT6hHw24jzYaYimvCo+/kSKuA9xNdtSu18ycox0
zKnXQ17s6aChMMt7Y8Nh4iz9BDejoOF6/b3sM0wRi+2/4j+6/GhcMRs0Og==
-----END CERTIFICTAE
Signature version: 1
Signature:
405C70D802B73947EDBF8D0D2C8180F10D4B3EF9694514219C579D2ED52F7D583E0F40813FC4E9F549B2EB1C21
725F7C
B1C79F98271E47E780E703E67472380FB52D4963E1D1FB9787B38E28B8E696570A180B7A2F131B1F174EA79F5D
B4765DF67386126D8
9E07EDF6C26E0A81272EA1437D03F2692937082756AE1F1BFAFBFACD6BE9CF9C84C961FACE9FA0FE64D85AE4FA
086969D0702C536ABD
B8FBFDC47C14C17D02FEBF4F7F5B24D2932FA876F56B4C07816270A0B4195C53D975C85AEAE3A74F2DBF293F52
423ECB7B853967080A
9C57DA3E4B08B2B2CA623B2CBAF7080A0AEB09B2E5B756970A3A27E0F1D17C8A243
```

Downgrading the Platform Image to an Older Version

Before you downgrade the platform image to an older version where the Secure Storage is not supported, you have to disable the feature in the version where it is supported. To disable Secure Storage, see Disabling Secure Storage, page 125

If you do not disable this feature before downgrading to an older image, the private-config file will be in an encrypted format. The following Syslog message will be generated to indicate that the file is in an encrypted format:

```
%PARSER-4-BADCFG: Unexpected end of configuration file.
```

If the file is in ‘plain text’, no Syslog message will be generated.