

About Cisco IOS Software Documentation

This chapter discusses the objectives, audience, organization, and conventions of Cisco IOS software documentation. It also provides sources for obtaining documentation from Cisco Systems.

Documentation Objectives

Cisco IOS software documentation describes the tasks and commands necessary to configure and maintain Cisco networking devices.

Audience

The Cisco IOS software documentation set is intended primarily for users who configure and maintain Cisco networking devices (such as routers and switches) but who may not be familiar with the tasks, the relationship between tasks, or the Cisco IOS software commands necessary to perform particular tasks. The Cisco IOS software documentation set is also intended for those users experienced with Cisco IOS software who need to know about new features, new configuration options, and new software characteristics in the current Cisco IOS software release.

Documentation Organization

The Cisco IOS software documentation set consists of documentation modules and master indexes. In addition to the main documentation set, there are supporting documents and resources.

Documentation Modules

The Cisco IOS documentation modules consist of configuration guides and corresponding command reference publications. Chapters in a configuration guide describe protocols, configuration tasks, and Cisco IOS software functionality and contain comprehensive configuration examples. Chapters in a command reference publication provide complete Cisco IOS command syntax information. Use each configuration guide in conjunction with its corresponding command reference publication.

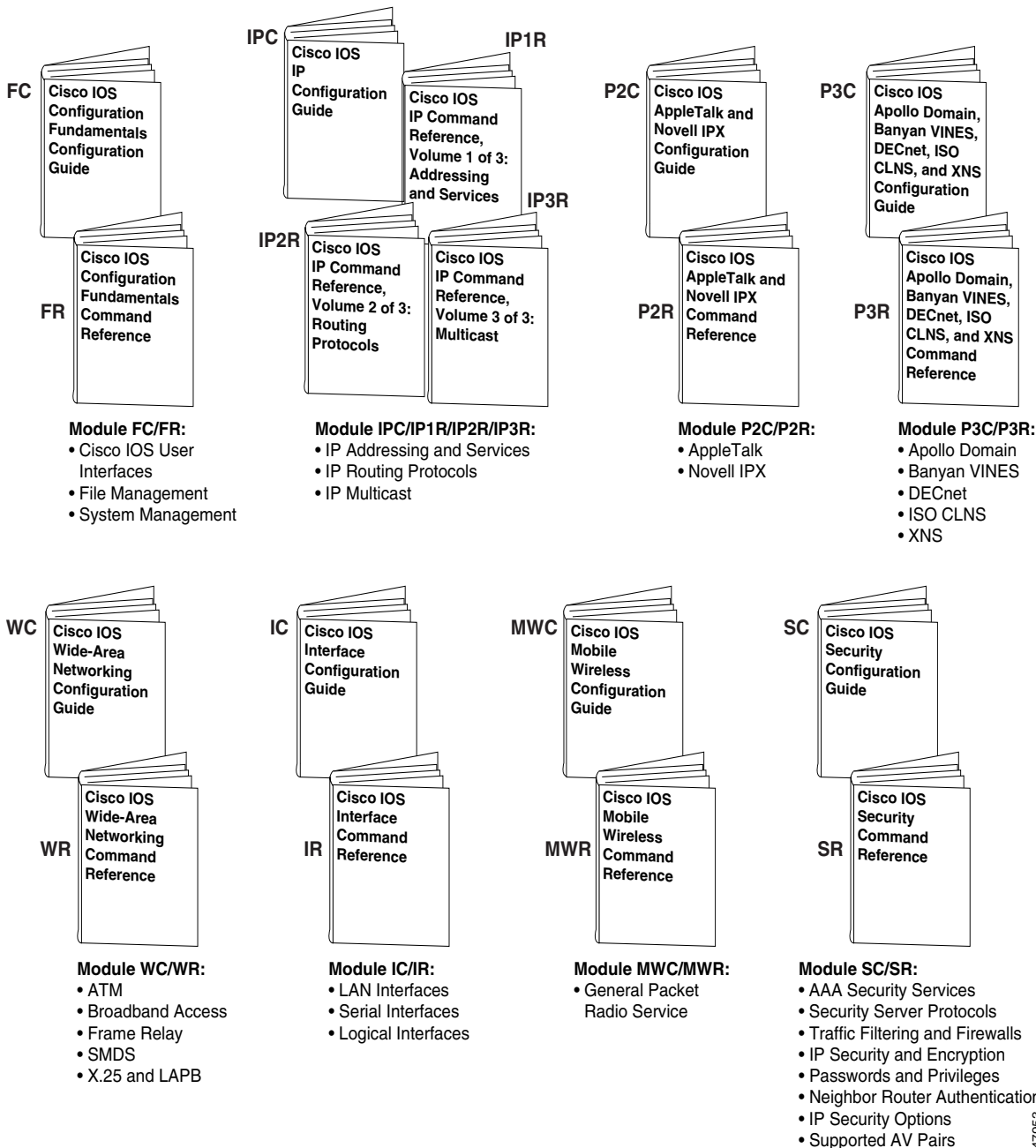
Figure 1 shows the Cisco IOS software documentation modules.



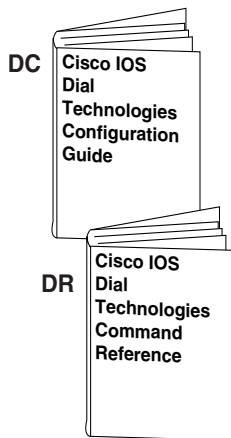
Note

The abbreviations (for example, FC and FR) next to the book icons are page designators, which are defined in a key in the index of each document to help you with navigation. The bullets under each module list the major technology areas discussed in the corresponding books.

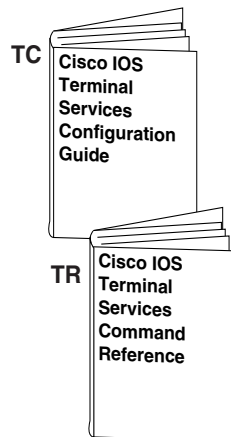
Figure 1 Cisco IOS Software Documentation Modules



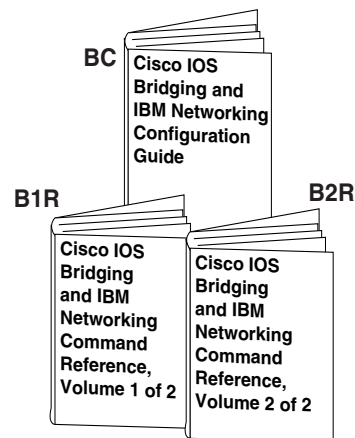
47953

**Module DC/DR:**

- Preparing for Dial Access
- Modem and Dial Shelf Configuration and Management
- ISDN Configuration
- Signalling Configuration
- Dial-on-Demand Routing Configuration
- Dial-Backup Configuration
- Dial-Related Addressing Services
- Virtual Templates, Profiles, and Networks
- PPP Configuration
- Callback and Bandwidth Allocation Configuration
- Dial Access Specialized Features
- Dial Access Scenarios

**Module TC/TR:**

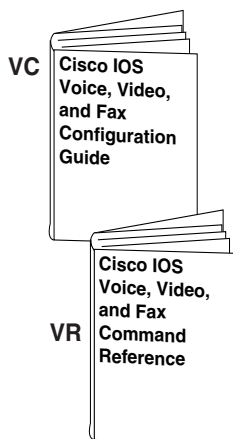
- ARA
- LAT
- NAS1
- Telnet
- TN3270
- XRemote
- X.28 PAD
- Protocol Translation

**Module BC/B1R:**

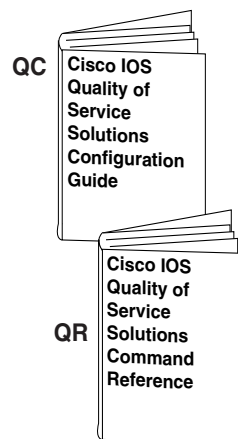
- Transparent Bridging
- SRB
- Token Ring Inter-Switch Link
- Token Ring Route Switch Module
- RSRB
- DLSw+
- Serial Tunnel and Block Serial Tunnel
- LLC2 and SDLC
- IBM Network Media Translation
- SNA Frame Relay Access
- NCIA Client/Server
- Airline Product Set

Module BC/B2R:

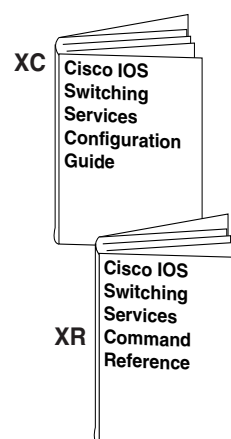
- DSPU and SNA Service Point
- SNA Switching Services
- Cisco Transaction Connection
- Cisco Mainframe Channel Connection
- CLAW and TCP/IP Offload
- CSNA, CMPC, and CMPC+
- TN3270 Server

**Module VC/VR:**

- Voice over IP
- Call Control Signalling
- Voice over Frame Relay
- Voice over ATM
- Telephony Applications
- Trunk Management
- Fax, Video, and Modem Support

**Module QC/QR:**

- Packet Classification
- Congestion Management
- Congestion Avoidance
- Policing and Shaping
- Signalling
- Link Efficiency Mechanisms

**Module XC/XR:**

- Cisco IOS Switching Paths
- NetFlow Switching
- Multiprotocol Label Switching
- Multilayer Switching
- Multicast Distributed Switching
- Virtual LANs
- LAN Emulation

47954

Master Indexes

Two master indexes provide indexing information for the Cisco IOS software documentation set: an index for the configuration guides and an index for the command references. Individual books also contain a book-specific index.

The master indexes provide a quick way for you to find a command when you know the command name but not which module contains the command. When you use the online master indexes, you can click the page number for an index entry and go to that page in the online document.

Supporting Documents and Resources

The following documents and resources support the Cisco IOS software documentation set:

- *Cisco IOS Command Summary* (three volumes)—This publication explains the function and syntax of the Cisco IOS software commands. For more information about defaults and usage guidelines, refer to the Cisco IOS command reference publications.
- *Cisco IOS System Error Messages*—This publication lists and describes Cisco IOS system error messages. Not all system error messages indicate problems with your system. Some are purely informational, and others may help diagnose problems with communications lines, internal hardware, or the system software.
- *Cisco IOS Debug Command Reference*—This publication contains an alphabetical listing of the **debug** commands and their descriptions. Documentation for each command includes a brief description of its use, command syntax, usage guidelines, and sample output.
- *Dictionary of Internetworking Terms and Acronyms*—This Cisco publication compiles and defines the terms and acronyms used in the internetworking industry.
- New feature documentation—The Cisco IOS software documentation set documents the mainline release of Cisco IOS software (for example, Cisco IOS Release 12.2). New software features are introduced in early deployment releases (for example, the Cisco IOS “T” release train for 12.2, 12.2(x)T). Documentation for these new features can be found in standalone documents called “feature modules.” Feature module documentation describes new Cisco IOS software and hardware networking functionality and is available on Cisco.com and the Documentation CD-ROM.
- Release notes—This documentation describes system requirements, provides information about new and changed features, and includes other useful information about specific software releases. See the section “Using Software Release Notes” in the chapter “Using Cisco IOS Software” for more information.
- Caveats documentation—This documentation provides information about Cisco IOS software defects in specific software releases.
- RFCs—RFCs are standards documents maintained by the Internet Engineering Task Force (IETF). Cisco IOS software documentation references supported RFCs when applicable. The full text of referenced RFCs may be obtained on the World Wide Web at <http://www.rfc-editor.org/>.
- MIBs—MIBs are used for network monitoring. For lists of supported MIBs by platform and release, and to download MIB files, see the Cisco MIB website on Cisco.com at <http://www.cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml>.

New and Changed Information

The following is new or changed information since the last release of the *Cisco IOS Security Configuration Guide*:

- A new chapter titled “Configuring Secure Shell” has been added to the section “Other Security Features.” This chapter describes SSH, which consists of a protocol and application that provide a secure replacement to the Berkeley r-tools.
- The “RADIUS Attributes” appendix has been expanded to include attribute information such as a RADIUS packet format description and RADIUS files. For more information, refer to the RADIUS Attributes appendix at the end of the book.
- The chapter titled “Configuring Cisco Encryption Technology” has been deleted from the section “IP Security and Encryption.” This functionality is no longer supported. For information regarding CET configuration, refer to *Cisco IOS Security Configuration Guide* release 12.1 or earlier.

Document Conventions

Within Cisco IOS software documentation, the term *router* is generally used to refer to a variety of Cisco products (for example, routers, access servers, and switches). Routers, access servers, and other networking devices that support Cisco IOS software are shown interchangeably within examples. These products are used only for illustrative purposes; that is, an example that shows one product does not necessarily indicate that other products are not supported.

The Cisco IOS documentation set uses the following conventions:

Convention	Description
^ or Ctrl	The ^ and Ctrl symbols represent the Control key. For example, the key combination ^D or Ctrl-D means hold down the Control key while you press the D key. Keys are indicated in capital letters but are not case sensitive.
<i>string</i>	A string is a nonquoted set of characters shown in italics. For example, when setting an SNMP community string to public, do not use quotation marks around the string or the string will include the quotation marks.

Command syntax descriptions use the following conventions:

Convention	Description
boldface	Boldface text indicates commands and keywords that you enter literally as shown.
<i>italics</i>	Italic text indicates arguments for which you supply values.
[x]	Square brackets enclose an optional element (keyword or argument).
	A vertical line indicates a choice within an optional or required set of keywords or arguments.
[x y]	Square brackets enclosing keywords or arguments separated by a vertical line indicate an optional choice.
{x y}	Braces enclosing keywords or arguments separated by a vertical line indicate a required choice.

Nested sets of square brackets or braces indicate optional or required choices within optional or required elements. For example:

Convention	Description
[x {y z}]	Braces and a vertical line within square brackets indicate a required choice within an optional element.

Examples use the following conventions:

Convention	Description
screen	Examples of information displayed on the screen are set in Courier font.
boldface screen	Examples of text that you must enter are set in Courier bold font.
< >	Angle brackets enclose text that is not printed to the screen, such as passwords.
!	An exclamation point at the beginning of a line indicates a comment line. (Exclamation points are also displayed by the Cisco IOS software for certain processes.)
[]	Square brackets enclose default responses to system prompts.

The following conventions are used to attract the attention of the reader:



Caution

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



Note

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



Timesaver

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

Obtaining Documentation

The following sections provide sources for obtaining documentation from Cisco Systems.

World Wide Web

The most current Cisco documentation is available on the World Wide Web at the following website:

<http://www.cisco.com>

Translated documentation is available at the following website:

http://www.cisco.com/public/countries_languages.html

Documentation CD-ROM

Cisco documentation and additional literature are available in a CD-ROM package, which ships with your product. The Documentation CD-ROM is updated monthly and may be more current than printed documentation. The CD-ROM package is available as a single unit or through an annual subscription.

Ordering Documentation

Cisco documentation can be ordered in the following ways:

- Registered Cisco Direct Customers can order Cisco product documentation from the Networking Products Marketplace:
http://www.cisco.com/cgi-bin/order/order_root.pl
- Registered Cisco.com users can order the Documentation CD-ROM through the online Subscription Store:
<http://www.cisco.com/go/subscription>
- Nonregistered Cisco.com users can order documentation through a local account representative by calling Cisco corporate headquarters (California, USA) at 408 526-7208 or, in North America, by calling 800 553-NETS(6387).

Documentation Feedback

If you are reading Cisco product documentation on the World Wide Web, you can submit technical comments electronically. Click **Feedback** in the toolbar and select **Documentation**. After you complete the form, click **Submit** to send it to Cisco.

You can e-mail your comments to bug-doc@cisco.com.

To submit your comments by mail, use the response card behind the front cover of your document, or write to the following address:

Cisco Systems, Inc.
Document Resource Connection
170 West Tasman Drive
San Jose, CA 95134-9883

We appreciate your comments.

Obtaining Technical Assistance

Cisco provides Cisco.com as a starting point for all technical assistance. Customers and partners can obtain documentation, troubleshooting tips, and sample configurations from online tools. For Cisco.com registered users, additional troubleshooting tools are available from the TAC website.

Cisco.com

Cisco.com is the foundation of a suite of interactive, networked services that provides immediate, open access to Cisco information and resources at anytime, from anywhere in the world. This highly integrated Internet application is a powerful, easy-to-use tool for doing business with Cisco.

Cisco.com provides a broad range of features and services to help customers and partners streamline business processes and improve productivity. Through Cisco.com, you can find information about Cisco and our networking solutions, services, and programs. In addition, you can resolve technical issues with online technical support, download and test software packages, and order Cisco learning materials and merchandise. Valuable online skill assessment, training, and certification programs are also available.

Customers and partners can self-register on Cisco.com to obtain additional personalized information and services. Registered users can order products, check on the status of an order, access technical support, and view benefits specific to their relationships with Cisco.

To access Cisco.com, go to the following website:

<http://www.cisco.com>

Technical Assistance Center

The Cisco TAC website is available to all customers who need technical assistance with a Cisco product or technology that is under warranty or covered by a maintenance contract.

Contacting TAC by Using the Cisco TAC Website

If you have a priority level 3 (P3) or priority level 4 (P4) problem, contact TAC by going to the TAC website:

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

P3 and P4 level problems are defined as follows:

- P3—Your network performance is degraded. Network functionality is noticeably impaired, but most business operations continue.
- P4—You need information or assistance on Cisco product capabilities, product installation, or basic product configuration.

In each of the above cases, use the Cisco TAC website to quickly find answers to your questions.

To register for Cisco.com, go to the following website:

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

If you cannot resolve your technical issue by using the TAC online resources, Cisco.com registered users can open a case online by using the TAC Case Open tool at the following website:

<http://www.cisco.com/tac/caseopen>

Contacting TAC by Telephone

If you have a priority level 1 (P1) or priority level 2 (P2) problem, contact TAC by telephone and immediately open a case. To obtain a directory of toll-free numbers for your country, go to the following website:

<http://www.cisco.com/warp/public/687/Directory/DirTAC.shtml>

P1 and P2 level problems are defined as follows:

- P1—Your production network is down, causing a critical impact to business operations if service is not restored quickly. No workaround is available.
- P2—Your production network is severely degraded, affecting significant aspects of your business operations. No workaround is available.



Using Cisco IOS Software

This chapter provides helpful tips for understanding and configuring Cisco IOS software using the command-line interface (CLI). It contains the following sections:

- Understanding Command Modes
- Getting Help
- Using the no and default Forms of Commands
- Saving Configuration Changes
- Filtering Output from the show and more Commands
- Identifying Supported Platforms

For an overview of Cisco IOS software configuration, refer to the *Cisco IOS Configuration Fundamentals Configuration Guide*.

For information on the conventions used in the Cisco IOS software documentation set, see the chapter “About Cisco IOS Software Documentation” located at the beginning of this book.

Understanding Command Modes

You use the CLI to access Cisco IOS software. Because the CLI is divided into many different modes, the commands available to you at any given time depend on the mode you are currently in. Entering a question mark (?) at the CLI prompt allows you to obtain a list of commands available for each command mode.

When you log in to the CLI, you are in user EXEC mode. User EXEC mode contains only a limited subset of commands. To have access to all commands, you must enter privileged EXEC mode, normally by using a password. From privileged EXEC mode you can issue any EXEC command—user or privileged mode—or you can enter global configuration mode. Most EXEC commands are one-time commands. For example, **show** commands show important status information, and **clear** commands clear counters or interfaces. The EXEC commands are not saved when the software reboots.

Configuration modes allow you to make changes to the running configuration. If you later save the running configuration to the startup configuration, these changed commands are stored when the software is rebooted. To enter specific configuration modes, you must start at global configuration mode. From global configuration mode, you can enter interface configuration mode and a variety of other modes, such as protocol-specific modes.

ROM monitor mode is a separate mode used when the Cisco IOS software cannot load properly. If a valid software image is not found when the software boots or if the configuration file is corrupted at startup, the software might enter ROM monitor mode.

Table 1 describes how to access and exit various common command modes of the Cisco IOS software. It also shows examples of the prompts displayed for each mode.

Table 1 Accessing and Exiting Command Modes

Command Mode	Access Method	Prompt	Exit Method
User EXEC	Log in.	Router>	Use the logout command.
Privileged EXEC	From user EXEC mode, use the enable EXEC command.	Router#	To return to user EXEC mode, use the disable command.
Global configuration	From privileged EXEC mode, use the configure terminal privileged EXEC command.	Router(config)#	To return to privileged EXEC mode from global configuration mode, use the exit or end command, or press Ctrl-Z .
Interface configuration	From global configuration mode, specify an interface using an interface command.	Router(config-if)#	To return to global configuration mode, use the exit command. To return to privileged EXEC mode, use the end command, or press Ctrl-Z .
ROM monitor	From privileged EXEC mode, use the reload EXEC command. Press the Break key during the first 60 seconds while the system is booting.	>	To exit ROM monitor mode, use the continue command.

For more information on command modes, refer to the “Using the Command-Line Interface” chapter in the *Cisco IOS Configuration Fundamentals Configuration Guide*.

Getting Help

Entering a question mark (?) at the CLI prompt displays a list of commands available for each command mode. You can also get a list of keywords and arguments associated with any command by using the context-sensitive help feature.

To get help specific to a command mode, a command, a keyword, or an argument, use one of the following commands:

Command	Purpose
help	Provides a brief description of the help system in any command mode.
<i>abbreviated-command-entry?</i>	Provides a list of commands that begin with a particular character string. (No space between command and question mark.)
<i>abbreviated-command-entry</i> <Tab>	Completes a partial command name.
?	Lists all commands available for a particular command mode.
<i>command ?</i>	Lists the keywords or arguments that you must enter next on the command line. (Space between command and question mark.)

Example: How to Find Command Options

This section provides an example of how to display syntax for a command. The syntax can consist of optional or required keywords and arguments. To display keywords and arguments for a command, enter a question mark (?) at the configuration prompt or after entering part of a command followed by a space. The Cisco IOS software displays a list and brief description of available keywords and arguments. For example, if you were in global configuration mode and wanted to see all the keywords or arguments for the **arap** command, you would type **arap ?**.

The <cr> symbol in command help output stands for “carriage return.” On older keyboards, the carriage return key is the Return key. On most modern keyboards, the carriage return key is the Enter key. The <cr> symbol at the end of command help output indicates that you have the option to press **Enter** to complete the command and that the arguments and keywords in the list preceding the <cr> symbol are optional. The <cr> symbol by itself indicates that no more arguments or keywords are available and that you must press **Enter** to complete the command.

Table 2 shows examples of how you can use the question mark (?) to assist you in entering commands. The table steps you through configuring an IP address on a serial interface on a Cisco 7206 router that is running Cisco IOS Release 12.0(3).

Table 2 *How to Find Command Options*

Command	Comment
Router> enable Password: <password> Router#	Enter the enable command and password to access privileged EXEC commands. You are in privileged EXEC mode when the prompt changes to Router#.
Router# configure terminal Enter configuration commands, one per line. End with CNTL/Z. Router(config)#	Enter the configure terminal privileged EXEC command to enter global configuration mode. You are in global configuration mode when the prompt changes to Router(config)#.
Router(config)# interface serial ? <0-6> Serial interface number Router(config)# interface serial 4 ? / Router(config)# interface serial 4/ ? <0-3> Serial interface number Router(config)# interface serial 4/0 Router(config-if)#	Enter interface configuration mode by specifying the serial interface that you want to configure using the interface serial global configuration command. Enter ? to display what you must enter next on the command line. In this example, you must enter the serial interface slot number and port number, separated by a forward slash. You are in interface configuration mode when the prompt changes to Router(config-if)#.

Table 2 *How to Find Command Options (continued)*

Command	Comment
Router(config-if)# ? Interface configuration commands: . . . ip Interface Internet Protocol config commands keepalive Enable keepalive lan-name LAN Name command llc2 LLC2 Interface Subcommands load-interval Specify interval for load calculation for an interface locaddr-priority Assign a priority group logging Configure logging for interface loopback Configure internal loopback on an interface mac-address Manually set interface MAC address mls mls router sub/interface commands mpoa MPOA interface configuration commands mtu Set the interface Maximum Transmission Unit (MTU) netbios Use a defined NETBIOS access list or enable name-caching no Negate a command or set its defaults nrzi-encoding Enable use of NRZI encoding ntp Configure NTP . . . Router(config-if)#	Enter ? to display a list of all the interface configuration commands available for the serial interface. This example shows only some of the available interface configuration commands.
Router(config-if)# ip ? Interface IP configuration subcommands: access-group Specify access control for packets accounting Enable IP accounting on this interface address Set the IP address of an interface authentication authentication subcommands bandwidth-percent Set EIGRP bandwidth limit broadcast-address Set the broadcast address of an interface cgmpp Enable/disable CGMP directed-broadcast Enable forwarding of directed broadcasts dvmrp DVMRP interface commands hello-interval Configures IP-EIGRP hello interval helper-address Specify a destination address for UDP broadcasts hold-time Configures IP-EIGRP hold time . . . Router(config-if)# ip	Enter the command that you want to configure for the interface. This example uses the ip command. Enter ? to display what you must enter next on the command line. This example shows only some of the available interface IP configuration commands.

Table 2 *How to Find Command Options (continued)*

Command	Comment
Router(config-if)# ip address ? A.B.C.D IP address negotiated IP Address negotiated over PPP Router(config-if)# ip address	<p>Enter the command that you want to configure for the interface. This example uses the ip address command.</p> <p>Enter ? to display what you must enter next on the command line. In this example, you must enter an IP address or the negotiated keyword.</p> <p>A carriage return (<cr>) is not displayed; therefore, you must enter additional keywords or arguments to complete the command.</p>
Router(config-if)# ip address 172.16.0.1 ? A.B.C.D IP subnet mask Router(config-if)# ip address 172.16.0.1	<p>Enter the keyword or argument you want to use. This example uses the 172.16.0.1 IP address.</p> <p>Enter ? to display what you must enter next on the command line. In this example, you must enter an IP subnet mask.</p> <p>A <cr> is not displayed; therefore, you must enter additional keywords or arguments to complete the command.</p>
Router(config-if)# ip address 172.16.0.1 255.255.255.0 ? secondary Make this IP address a secondary address <cr> Router(config-if)# ip address 172.16.0.1 255.255.255.0	<p>Enter the IP subnet mask. This example uses the 255.255.255.0 IP subnet mask.</p> <p>Enter ? to display what you must enter next on the command line. In this example, you can enter the secondary keyword, or you can press Enter.</p> <p>A <cr> is displayed; you can press Enter to complete the command, or you can enter another keyword.</p>
Router(config-if)# ip address 172.16.0.1 255.255.255.0 Router(config-if)#	<p>In this example, Enter is pressed to complete the command.</p>

Using the no and default Forms of Commands

Almost every configuration command has a **no** form. In general, use the **no** form to disable a function. Use the command without the **no** keyword to reenable a disabled function or to enable a function that is disabled by default. For example, IP routing is enabled by default. To disable IP routing, use the **no ip routing** command; to reenable IP routing, use the **ip routing** command. The Cisco IOS software command reference publications provide the complete syntax for the configuration commands and describe what the **no** form of a command does.

Configuration commands also can have a **default** form, which returns the command settings to the default values. Most commands are disabled by default, so in such cases using the **default** form has the same result as using the **no** form of the command. However, some commands are enabled by default

and have variables set to certain default values. In these cases, the **default** form of the command enables the command and sets the variables to their default values. The Cisco IOS software command reference publications describe the effect of the **default** form of a command if the command functions differently than the **no** form.

Saving Configuration Changes

Use the **copy system:running-config nvram:startup-config** command to save your configuration changes to the startup configuration so that the changes will not be lost if the software reloads or a power outage occurs. For example:

```
Router# copy system:running-config nvram:startup-config
Building configuration...
```

It might take a minute or two to save the configuration. After the configuration has been saved, the following output appears:

```
[OK]
Router#
```

On most platforms, this task saves the configuration to NVRAM. On the Class A Flash file system platforms, this task saves the configuration to the location specified by the CONFIG_FILE environment variable. The CONFIG_FILE variable defaults to NVRAM.

Filtering Output from the show and more Commands

In Cisco IOS Release 12.0(1)T and later releases, you can search and filter the output of **show** and **more** commands. This functionality is useful if you need to sort through large amounts of output or if you want to exclude output that you need not see.

To use this functionality, enter a **show** or **more** command followed by the “pipe” character (|); one of the keywords **begin**, **include**, or **exclude**; and a regular expression on which you want to search or filter (the expression is case-sensitive):

```
command | {begin | include | exclude} regular-expression
```

The output matches certain lines of information in the configuration file. The following example illustrates how to use output modifiers with the **show interface** command when you want the output to include only lines in which the expression “protocol” appears:

```
Router# show interface | include protocol

FastEthernet0/0 is up, line protocol is up
Serial4/0 is up, line protocol is up
Serial4/1 is up, line protocol is up
Serial4/2 is administratively down, line protocol is down
Serial4/3 is administratively down, line protocol is down
```

For more information on the search and filter functionality, refer to the “Using the Command-Line Interface” chapter in the *Cisco IOS Configuration Fundamentals Configuration Guide*.

Identifying Supported Platforms

Cisco IOS software is packaged in feature sets consisting of software images that support specific platforms. The feature sets available for a specific platform depend on which Cisco IOS software images are included in a release. To identify the set of software images available in a specific release or to find out if a feature is available in a given Cisco IOS software image, see the following sections:

- Using Feature Navigator
- Using Software Release Notes

Using Feature Navigator

Feature Navigator is a web-based tool that enables you to quickly determine which Cisco IOS software images support a particular set of features and which features are supported in a particular Cisco IOS image.

Feature Navigator is available 24 hours a day, 7 days a week. To access Feature Navigator, you must have an account on Cisco.com. If you have forgotten or lost your account information, e-mail the Contact Database Administration group at cdbadmin@cisco.com. If you do not have an account on Cisco.com, go to <http://www.cisco.com/register> and follow the directions to establish an account.

To use Feature Navigator, you must have a JavaScript-enabled web browser such as Netscape 3.0 or later, or Internet Explorer 4.0 or later. Internet Explorer 4.0 always has JavaScript enabled. To enable JavaScript for Netscape 3.x or Netscape 4.x, follow the instructions provided with the web browser. For JavaScript support and enabling instructions for other browsers, check with the browser vendor.

Feature Navigator is updated when major Cisco IOS software releases and technology releases occur. You can access Feature Navigator at the following URL:

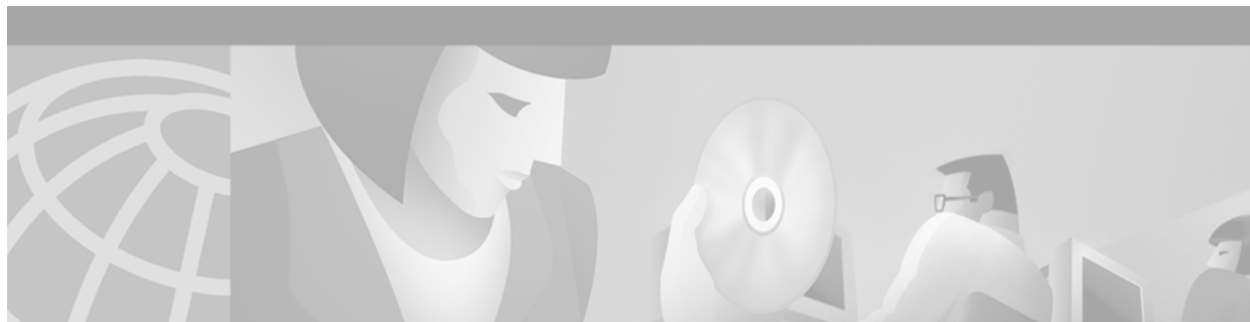
<http://www.cisco.com/go/fn>

Using Software Release Notes

Cisco IOS software releases include release notes that provide the following information:

- Platform support information
- Memory recommendations
- Microcode support information
- Feature set tables
- Feature descriptions
- Open and resolved severity 1 and 2 caveats for all platforms

Release notes are intended to be release-specific for the most current release, and the information provided in these documents may not be cumulative in providing information about features that first appeared in previous releases.



Security Overview

This chapter contains the following sections:

- [About This Guide](#)

Preview the topics in this guide.

- [Creating Effective Security Policies](#)

Learn tips and hints for creating a security policy for your organization. A security policy should be finalized and up to date *before* you configure any security features.

- [Identifying Security Risks and Cisco IOS Solutions](#)

Identify common security risks that might be present in your network, and find the right Cisco IOS security feature to prevent security break-ins.

About This Guide

The *Cisco IOS Security Configuration Guide* describes how to configure Cisco IOS security features for your Cisco networking devices. These security features can protect your network against degradation or failure and also against data loss or compromise resulting from intentional attacks and from unintended but damaging mistakes by well-meaning network users.

This guide is divided into five parts:

- [Authentication, Authorization, and Accounting \(AAA\)](#)
- [Security Server Protocols](#)
- [Traffic Filtering and Firewalls](#)
- [IP Security and Encryption](#)
- [Other Security Features](#)

[Appendixes](#) follow the five main divisions.

The following sections briefly describe each of these parts and the appendixes.

Authentication, Authorization, and Accounting (AAA)

This part describes how to configure Cisco's authentication, authorization, and accounting (AAA) paradigm. AAA is an architectural framework for configuring a set of three independent security functions in a consistent, modular manner.

- **Authentication**—Provides the method of identifying users, including login and password dialog, challenge and response, messaging support, and, depending on the security protocol you select, encryption. Authentication is the way a user is identified prior to being allowed access to the network and network services. You configure AAA authentication by defining a named list of authentication methods and then applying that list to various interfaces.
- **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, IPX, ARA, and Telnet.

Remote security servers, such as RADIUS and TACACS+, authorize users for specific rights by associating attribute-value (AV) pairs, which define those rights, with the appropriate user. AAA authorization works by assembling a set of attributes that describe what the user is authorized to perform. These attributes are compared with the information contained in a database for a given user, and the result is returned to AAA to determine the user's actual capabilities and restrictions.

- **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. Accounting enables you to track the services users are accessing, as well as the amount of network resources they are consuming.

**Note**

You can configure authentication outside of AAA. However, you must configure AAA if you want to use RADIUS, TACACS+, or Kerberos or if you want to configure a backup authentication method.

Security Server Protocols

In many circumstances, AAA uses security protocols to administer its security functions. If your router or access server 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.

The chapters in this part describe how to configure the following security server protocols:

- **RADIUS**—A distributed client/server system implemented through AAA that secures networks against unauthorized access. In the Cisco implementation, RADIUS clients run on Cisco routers and send authentication requests to a central RADIUS server that contains all user authentication and network service access information.
- **TACACS+**—A security application implemented through AAA that provides centralized validation of users attempting to gain access to a router or network access server. TACACS+ services are maintained in a database on a TACACS+ daemon running, typically, on a UNIX or Windows NT workstation. TACACS+ provides for separate and modular authentication, authorization, and accounting facilities.
- **Kerberos**—A secret-key network authentication protocol implemented through AAA that uses the Data Encryption Standard (DES) cryptographic algorithm for encryption and authentication. Kerberos was designed to authenticate requests for network resources. Kerberos is based on the concept of a trusted third party that performs secure verification of users and services. The primary use of Kerberos is to verify that users and the network services they use are really who and what

they claim to be. To accomplish this, a trusted Kerberos server issues tickets to users. These tickets, which have a limited lifespan, are stored in a user's credential cache and can be used in place of the standard username-and-password authentication mechanism.

Traffic Filtering and Firewalls

This part describes how to configure your networking devices to filter traffic or to function as a firewall.

- Cisco implements traffic filters with access control lists (also called access lists). Access lists determine what traffic is blocked and what traffic is forwarded at router interfaces. Cisco provides both basic and advanced access list capabilities.
 - Basic access lists

An overview of basic access lists is in the chapter “Access Control Lists: Overview and Guidelines.” This chapter describes tips, cautions, considerations, recommendations, and general guidelines for configuring access lists for the various network protocols. You should configure basic access lists for all network protocols that will be routed through your networking device, such as IP, IPX, AppleTalk, and so forth.
 - Advanced access lists

The advanced access list capabilities and configuration are described in the remaining chapters in the “Traffic Filtering and Firewalls” part of this document. The advanced access lists provide sophisticated and dynamic traffic filtering capabilities for stronger, more flexible network security.
- Cisco IOS Firewall provides an extensive set of security features, allowing you to configure a simple or elaborate firewall, according to your particular requirements. The following features are key components of Cisco IOS Firewall:
 - Context-based Access Control (CBAC)

CBAC intelligently filters TCP and UDP packets based on application-layer protocol session information. You can configure CBAC to permit specified TCP and UDP traffic through a firewall only when the connection is initiated from within the network you want to protect. CBAC can inspect traffic for sessions that originate from either side of the firewall, and CBAC can be used for intranet, extranet, and Internet perimeters of your network.
 - Cisco IOS Firewall Intrusion Detection System (IDS)

The Cisco IOS Firewall IDS supports intrusion detection technology for mid-range and high-end router platforms with firewall support. It identifies 59 of the most common attacks using “signatures” to detect patterns of misuse in network traffic. The Cisco IOS Firewall IDS acts as an in-line intrusion detection sensor, watching packets and sessions as they flow through the router, scanning each to match any of the IDS signatures. When it detects suspicious activity, it responds before network security can be compromised and logs the event through Cisco IOS syslog.

Cisco IOS Firewall IDS is compatible with the Cisco Secure Intrusion Detection System (formally known as NetRanger)—an enterprise-scale, real-time intrusion detection system designed to detect, report, and terminate unauthorized activity throughout a network.
 - Authentication Proxy

The Cisco IOS Firewall authentication proxy feature allows network administrators to apply specific security policies on a per-user basis. Previously, user identity and related authorized access were associated with a user's IP address, or a single security policy had to be applied to

an entire user group or sub network. Now, users can be identified and authorized on the basis of their per-user policy, and access privileges tailored on an individual basis are possible, as opposed to general policy applied across multiple users.

- Port to Application Mapping (PAM)

Port to Application Mapping (PAM) is a feature of Cisco Secure Integrated Software. PAM allows you to customize TCP or UDP port numbers for network services or applications. PAM uses this information to support network environments that run services using ports that are different from the registered or well-known ports associated with an application. For example, the information in the PAM table enables Context-based Access Control (CBAC) supported services to run on non-standard ports.

Firewalls are discussed in the chapters “Cisco IOS Firewall Overview” and “Configuring Context-Based Access Control.”

IP Security and Encryption

This part describes how to configure IP security and encryption in the following chapters:

- Configuring IPSec Network Security

This chapter describes how to configure IPSec. IPSec provides security for transmission of sensitive information over unprotected networks such as the Internet. IPSec provides data authentication and anti-replay services in addition to data confidentiality services.

- Configuring Certification Authority Interoperability

This chapter describes how to configure certification authority (CA) interoperability. CA interoperability permits Cisco IOS devices and CAs to communicate so that your Cisco IOS device can obtain and use digital certificates from the CA.

- Configuring Internet Key Exchange Security Protocol

This chapter describes how to configure Internet Key Exchange (IKE). IKE is a key management protocol standard that is used in conjunction with the IPSec standard. IPSec can be configured without IKE, but IKE enhances IPSec by providing additional features, flexibility, and ease of configuration for the IPSec standard.

Other Security Features

This part describes four important security features in the following chapters:

- Configuring Passwords and Privileges

This chapter describes how to configure static passwords stored on your networking device. These passwords are used to control access to the device’s command line prompt to view or change the device configuration.

This chapter also describes how to assign privilege levels to the passwords. You can configure up to 16 different privilege levels and assign each level to a password. For each privilege level you define a subset of Cisco IOS commands that can be executed. You can use these different levels to allow some users the ability to execute all Cisco IOS commands, and to restrict other users to a defined subset of commands.

This chapter also describes how to recover lost passwords.

- Neighbor Router Authentication: Overview and Guidelines

This chapter briefly describes the security benefits and operation of neighbor router authentication.

When neighbor authentication is configured on a router, the router authenticates its neighbor router before accepting any route updates from that neighbor. This ensures that a router always receives reliable routing update information from a trusted source.

- Configuring IP Security Options

This chapter describes how to configure IP Security Options (IPSO) as described in RFC 1108.

IPSO is generally used to comply with the security policy of the U.S. government's Department of Defense.

- Configuring Unicast Reverse Path Forwarding

This chapter describes the Unicast Reverse Path Forwarding (Unicast RPF) feature, which helps mitigate problems caused by the introduction of malformed or forged (spoofed) IP source addresses into a network by discarding IP packets that lack a verifiable IP source address. For example, a number of common types of denial-of-service (DoS) attacks, including Smurf and Tribe Flood Network (TFN), can take advantage of forged or rapidly changing source IP addresses to allow attackers to thwart efforts to locate or filter the attacks. For Internet service providers (ISPs) that provide public access, Unicast RPF deflects such attacks by forwarding only packets that have source addresses that are valid and consistent with the IP routing table. This action protects the network of the ISP, its customer, and the rest of the Internet.

- Configuring Secure Shell

This chapter describes the Secure Shell (SSH) feature. SSH is an application and a protocol that provides a secure replacement to a suite of Unix r-commands such as rsh, rlogin and rcp. (Cisco IOS supports rlogin.) The protocol secures the sessions using standard cryptographic mechanisms, and the application can be used similarly to the Berkeley rexec and rsh tools. There are currently two versions of SSH available: SSH Version 1 and SSH Version 2. Only SSH Version 1 is implemented in the Cisco IOS software.

Appendixes

The appendixes describe the supported RADIUS attributes and TACACS+ attribute-value pairs as follows:

- RADIUS Attributes

RADIUS attributes are used to define specific AAA elements in a user profile, which is stored on the RADIUS daemon. This appendix lists the RADIUS attributes currently supported.

- TACACS+ Attribute-Value Pairs

TACACS+ attribute-value pairs are used to define specific AAA elements in a user profile, which is stored on the TACACS+ daemon. This appendix lists the TACACS+ attribute-value pairs currently supported.

Creating Effective Security Policies

An effective security policy works to ensure that your organization's network assets are protected from sabotage and from inappropriate access—both intentional and accidental.

All network security features should be configured in compliance with your organization's security policy. If you do not have a security policy, or if your policy is out of date, you should ensure that the policy is created or updated before you decide how to configure security on your Cisco device.

The following sections provide guidelines to help you create an effective security policy:

- [The Nature of Security Policies](#)
- [Two Levels of Security Policies](#)
- [Tips for Developing an Effective Security Policy](#)

The Nature of Security Policies

You should recognize these aspects of security policies:

- Security policies represent trade-offs.

With all security policies, there is some trade-off between user productivity and security measures that can be restrictive and time consuming. The goal of any security design is to provide maximum security with minimum impact on user access and productivity. Some security measures, such as network data encryption, do not restrict access and productivity. On the other hand, cumbersome or unnecessarily redundant verification and authorization systems can frustrate users and even prevent access to critical network resources.

- Security policies should be determined by business needs.

Business needs should dictate the security policy; a security policy should not determine how a business operates.

- Security policies are living documents.

Because organizations are constantly subject to change, security policies must be systematically updated to reflect new business directions, technological changes, and resource allocations.

Two Levels of Security Policies

You can think of a security policy as having two levels: a requirements level and an implementation level.

- At the requirements level, a policy defines the degree to which your network assets must be protected against intrusion or destruction and also estimates the cost (consequences) of a security breach. For example, the policy could state that only human resources personnel should be able to access personnel records, or that only IS personnel should be able to configure the backbone routers. The policy could also address the consequences of a network outage (due to sabotage), and the consequences of inadvertently making sensitive information public.
- At the implementation level, a policy defines guidelines to implement the requirements-level policy, using specific technology in a predefined way. For example, the implementation-level policy could require access lists to be configured so that only traffic from human resources host computers can access the server containing personnel records.

When creating a policy, define security requirements before defining security implementations so that you do not end up merely justifying particular technical solutions that might not actually be required.

Tips for Developing an Effective Security Policy

To develop an effective security policy, consider the recommendations in the following sections:

- [Identifying Your Network Assets to Protect](#)
- [Determining Points of Risk](#)
- [Limiting the Scope of Access](#)
- [Identifying Assumptions](#)
- [Determining the Cost of Security Measures](#)
- [Considering Human Factors](#)
- [Keeping a Limited Number of Secrets](#)
- [Implementing Pervasive and Scalable Security](#)
- [Understanding Typical Network Functions](#)
- [Remembering Physical Security](#)

Identifying Your Network Assets to Protect

The first step to developing a security policy is to understand and identify your organization's network assets. Network assets include the following:

- Networked hosts (such as PCs; includes the hosts' operating systems, applications, and data)
- Networking devices (such as routers)
- Network data (data that travels across the network)

You must both identify your network's assets and determine the degree to which each of these assets must be protected. For example, one subnetwork of hosts might contain extremely sensitive data that should be protected at all costs, while a different subnetwork of hosts might require only modest protection against security risks because there is less cost involved if the subnetwork is compromised.

Determining Points of Risk

You must understand how potential intruders can enter your organization's network or sabotage network operation. Special areas of consideration are network connections, dial-up access points, and misconfigured hosts. Misconfigured hosts, frequently overlooked as points of network entry, can be systems with unprotected login accounts (guest accounts), employ extensive trust in remote commands (such as rlogin and rsh), have illegal modems attached to them, and use easy-to-break passwords.

Limiting the Scope of Access

Organizations can create multiple barriers within networks, so that unlawful entry to one part of the system does not automatically grant entry to the entire infrastructure. Although maintaining a high level of security for the entire network can be prohibitively expensive (in terms of systems and equipment as well as productivity), you can often provide higher levels of security to the more sensitive areas of your network.

Identifying Assumptions

Every security system has underlying assumptions. For example, an organization might assume that its network is not tapped, that intruders are not very knowledgeable, that intruders are using standard software, or that a locked room is safe. It is important to identify, examine, and justify your assumptions: any hidden assumption is a potential security hole.

Determining the Cost of Security Measures

In general, providing security comes at a cost. This cost can be measured in terms of increased connection times or inconveniences to legitimate users accessing the assets, or in terms of increased network management requirements, and sometimes in terms of actual dollars spent on equipment or software upgrades.

Some security measures inevitably inconvenience some sophisticated users. Security can delay work, create expensive administrative and educational overhead, use significant computing resources, and require dedicated hardware.

When you decide which security measures to implement, you must understand their costs and weigh these against potential benefits. If the security costs are out of proportion to the actual dangers, it is a disservice to the organization to implement them.

Considering Human Factors

If security measures interfere with essential uses of the system, users resist these measures and sometimes even circumvent them. Many security procedures fail because their designers do not take this fact into account. For example, because automatically generated “nonsense” passwords can be difficult to remember, users often write them on the undersides of keyboards. A “secure” door that leads to a system’s only tape drive is sometimes propped open. For convenience, unauthorized modems are often connected to a network to avoid cumbersome dial-in security procedures. To ensure compliance with your security measures, users must be able to get their work done as well as understand and accept the need for security.

Any user can compromise system security to some degree. For example, an intruder might learn passwords by simply calling legitimate users on the telephone claiming to be a system administrator and asking for them. If users understand security issues and understand the reasons for them, they are far less likely to compromise security in this way.

Defining such human factors and any corresponding policies needs to be included as a formal part of your complete security policy.

At a minimum, users must be taught never to release passwords or other secrets over unsecured telephone lines (especially through cordless or cellular telephones) or electronic mail. They should be wary of questions asked by people who call them on the telephone. Some companies have implemented formalized network security training for their employees in which employees are not allowed access to the network until they have completed a formal training program.

Keeping a Limited Number of Secrets

Most security is based on secrets; for example, passwords and encryption keys are secrets. But the more secrets there are, the harder it is to keep all of them. It is prudent, therefore, to design a security policy that relies on a limited number of secrets. Ultimately, the most important secret an organization has is the information that can help someone circumvent its security.

Implementing Pervasive and Scalable Security

Use a systematic approach to security that includes multiple, overlapping security methods.

Almost any change that is made to a system can affect security. This is especially true when new services are created. System administrators, programmers, and users need to consider the security implications of every change they make. Understanding the security implications of a change takes practice; it requires lateral thinking and a willingness to explore every way that a service could potentially be manipulated. The goal of any security policy is to create an environment that is not susceptible to every minor change.

Understanding Typical Network Functions

Understand how your network system normally functions, know what is expected and unexpected behavior, and be familiar with how devices are usually used. This kind of awareness helps the organization detect security problems. Noticing unusual events can help catch intruders before they can damage the system. Software auditing tools can help detect, log, and track unusual events. In addition, an organization should know exactly what software it relies on to provide auditing trails, and a security system should not operate on the assumption that all software is bug free.

Remembering Physical Security

The physical security of your network devices and hosts cannot be neglected. For example, many facilities implement physical security by using security guards, closed circuit television, card-key entry systems, or other means to control physical access to network devices and hosts. Physical access to a computer or router usually gives a sophisticated user complete control over that device. Physical access to a network link usually allows a person to tap into that link, jam it, or inject traffic into it. Software security measures can often be circumvented when access to the hardware is not controlled.

Identifying Security Risks and Cisco IOS Solutions

Cisco IOS software provides a comprehensive set of security features to guard against specific security risks. This section describes a few common security risks that might be present in your network, and describes how to use Cisco IOS software to protect against each of these risks:

- [Preventing Unauthorized Access into Networking Devices](#)
- [Preventing Unauthorized Access into Networks](#)
- [Preventing Network Data Interception](#)
- [Preventing Fraudulent Route Updates](#)

Preventing Unauthorized Access into Networking Devices

If someone were to gain console or terminal access into a networking device, such as a router, switch, or network access server, that person could do significant damage to your network—perhaps by reconfiguring the device, or even by simply viewing the device's configuration information.

Typically, you want administrators to have access to your networking device; you do not want other users on your local-area network or those dialing in to the network to have access to the router.

Users can access Cisco networking devices by dialing in from outside the network through an asynchronous port, connecting from outside the network through a serial port, or connecting via a terminal or workstation from within the local network.

To prevent unauthorized access into a networking device, you should configure one or more of the following security features:

- At a minimum, you should configure passwords and privileges at each networking device for all device lines and ports, as described in the chapter “Configuring Passwords and Privileges.” These passwords are stored on the networking device. When users attempt to access the device through a particular line or port, they must enter the password applied to the line or port before they can access the device.
- For an additional layer of security, you can also configure username/password pairs, stored in a database on the networking device, as described in the chapter “Configuring Passwords and Privileges.” These pairs are assigned to lines or interfaces and authenticate each user before that user can access the device. If you have defined privilege levels, you can also assign a specific privilege level (with associated rights and privileges) to each username/password pair.
- If you want to use username/password pairs, but you want to store them centrally instead of locally on each individual networking device, you can store them in a database on a security server. Multiple networking devices can then use the same database to obtain user authentication (and, if necessary, authorization) information. Cisco supports a variety of security server protocols, such as RADIUS, TACACS+, and Kerberos. If you decide to use the database on a security server to store login username/password pairs, you must configure your router or access server to support the applicable protocol; in addition, because most supported security protocols must be administered through the AAA security services, you will probably need to enable AAA. For more information about security protocols and AAA, refer to the chapters in the “Authentication, Authorization, and Accounting (AAA)” part of this document.



Note Cisco recommends that, whenever possible, AAA be used to implement authentication.

- If you want to authorize individual users for specific rights and privileges, you can implement AAA’s authorization feature, using a security protocol such as TACACS+ or RADIUS. For more information about security protocol features and AAA, refer to the chapters in the “Authentication, Authorization, and Accounting (AAA)” part of this document.
- If you want to have a backup authentication method, you must configure AAA. AAA allows you to specify the primary method for authenticating users (for example, a username/password database stored on a TACACS+ server) and then specify backup methods (for example, a locally stored username/password database.) The backup method is used if the primary method’s database cannot be accessed by the networking device. To configure AAA, refer to the chapters in the “Authentication, Authorization, and Accounting (AAA)” part of this document. You can configure up to four sequential backup methods.



Note If you do not have backup methods configured, you will be denied access to the device if the username/password database cannot be accessed for any reason.

- If you want to keep an audit trail of user access, configure AAA accounting as described in the chapter “Configuring Accounting.”

Preventing Unauthorized Access into Networks

If someone were to gain unauthorized access to your organization's internal network, that person could cause damage in many ways, perhaps by accessing sensitive files from a host, by planting a virus, or by hindering network performance by flooding your network with illegitimate packets.

This risk can also apply to a person within your network attempting to access another internal network such as a Research and Development subnetwork with sensitive and critical data. That person could intentionally or inadvertently cause damage; for example, that person might access confidential files or tie up a time-critical printer.

To prevent unauthorized access through a networking device into a network, you should configure one or more of these security features:

- **Traffic Filtering**

Cisco uses access lists to filter traffic at networking devices. Basic access lists allow only specified traffic through the device; other traffic is simply dropped. You can specify individual hosts or subnets that should be allowed into the network, and you can specify what type of traffic should be allowed into the network. Basic access lists generally filter traffic based on source and destination addresses, and protocol type of each packet.

Advanced traffic filtering is also available, providing additional filtering capabilities; for example, the Lock-and-Key Security feature requires each user to be authenticated via a username/password before that user's traffic is allowed onto the network.

All the Cisco IOS traffic filtering capabilities are described in the chapters in the "Traffic Filtering and Firewalls" part of this document.

- **Authentication**

You can require users to be authenticated before they gain access into a network. When users attempt to access a service or host (such as a web site or file server) within the protected network, they must first enter certain data such as a username and password, and possibly additional information such as their date of birth or mother's maiden name. After successful authentication (depending on the method of authentication), users will be assigned specific privileges, allowing them to access specific network assets. In most cases, this type of authentication would be facilitated by using CHAP or PAP over a serial PPP connection in conjunction with a specific security protocol, such as TACACS+ or RADIUS.

Just as in preventing unauthorized access to specific network devices, you need to decide whether or not you want the authentication database to reside locally or on a separate security server. In this case, a local security database is useful if you have very few routers providing network access. A local security database does not require a separate (and costly) security server. A remote, centralized security database is convenient when you have a large number of routers providing network access because it prevents you from having to update each router with new or changed username authentication and authorization information for potentially hundreds of thousands of dial-in users. A centralized security database also helps establish consistent remote access policies throughout a corporation.

Cisco IOS software supports a variety of authentication methods. Although AAA is the primary (and recommended) method for access control, Cisco IOS software provides additional features for simple access control that are outside the scope of AAA. For more information, refer to the chapter "Configuring Authentication."

Preventing Network Data Interception

When packets travel across a network, they are susceptible to being read, altered, or “hijacked.” (Hijacking occurs when a hostile party intercepts a network traffic session and poses as one of the session endpoints.)

If the data is traveling across an unsecured network such as the Internet, the data is exposed to a fairly significant risk. Sensitive or confidential data could be exposed, critical data could be modified, and communications could be interrupted if data is altered.

To protect data as it travels across a network, configure network data encryption, as described in the chapter “Configuring IPSec Network Security.”

IPSec provides the following network security services. These services are optional. In general, local security policy will dictate the use of one or more of the following services:

- **Data Confidentiality**—The IPSec sender can encrypt packets before transmitting them across a network.
- **Data Integrity**—The IPSec receiver can authenticate packets sent by the IPSec sender to ensure that the data has not been altered during transmission.
- **Data Origin Authentication**—The IPSec receiver can authenticate the source of the IPSec packets sent. This service is dependent upon the data integrity service.
- **Anti-Replay**—The IPSec receiver can detect and reject replayed packets.

Cisco IPSec prevents routed traffic from being examined or tampered with while it travels across a network. This feature causes IP packets to be encrypted at a Cisco router, routed across a network as encrypted information, and decrypted at the destination Cisco router. In between the two routers, the packets are in encrypted form and therefore the packets’ contents cannot be read or altered. You define what traffic should be encrypted between the two routers, according to what data is more sensitive or critical.

If you want to protect traffic for protocols other than IP, you can encapsulate those other protocols into IP packets using GRE encapsulation, and then encrypt the IP packets.

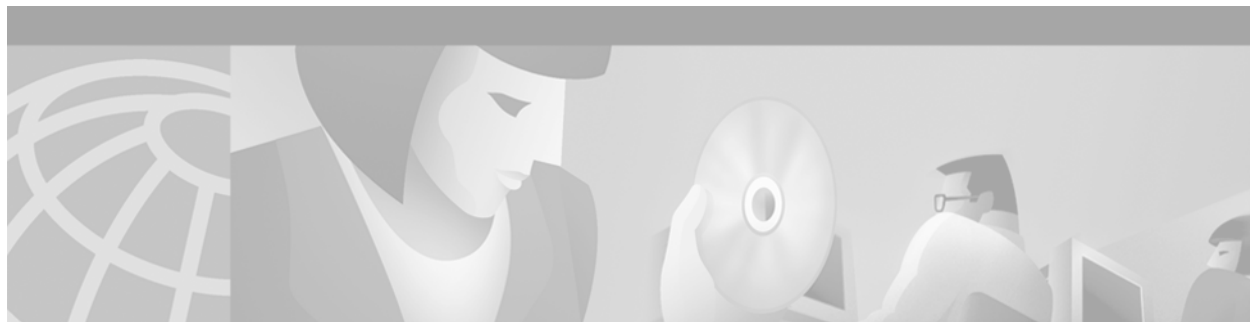
Typically, you do not use IPSec for traffic that is routed through networks that you consider secure. Consider using IPSec for traffic that is routed across unsecured networks, such as the Internet, if your organization could be damaged if the traffic is examined or tampered with by unauthorized individuals.

Preventing Fraudulent Route Updates

All routing devices determine where to route individual packets by using information stored in route tables. This route table information is created using route updates obtained from neighboring routers.

If a router receives a fraudulent update, the router could be tricked into forwarding traffic to the wrong destination. This could cause sensitive data to be exposed, or could cause network communications to be interrupted.

To ensure that route updates are received only from known, trusted neighbor routers, configure neighbor router authentication as described in the chapter “Neighbor Router Authentication: Overview and Guidelines.”



AAA Overview

Access control is the way you control who is allowed access to the network server and what services they are allowed to use once they have access. Authentication, authorization, and accounting (AAA) network security services provide the primary framework through which you set up access control on your router or access server.

In This Chapter

This chapter includes the following sections:

- [About AAA Security Services](#)
- [Where to Begin](#)
- [What to Do Next](#)

About AAA Security Services

AAA is an architectural framework for configuring a set of three independent security functions in a consistent manner. AAA provides a modular way of performing the following services:

- **Authentication**—Provides the method of identifying users, including login and password dialog, challenge and response, messaging support, and, depending on the security protocol you select, encryption.

Authentication is the way a user is identified prior to being allowed access to the network and network services. You configure AAA authentication by defining a named list of authentication methods, and then applying that list to various interfaces. The method list defines the types of authentication to be performed and the sequence in which they will be performed; it must be applied to a specific interface before any of the defined authentication methods will be performed. The only exception is the default method list (which is named “default”). The default method list is automatically applied to all interfaces if no other method list is defined. A defined method list overrides the default method list.

All authentication methods, except for local, line password, and enable authentication, must be defined through AAA. For information about configuring all authentication methods, including those implemented outside of the AAA security services, refer to the chapter “Configuring Authentication.”

- **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, IPX, ARA, and Telnet.

AAA authorization works by assembling a set of attributes that describe what the user is authorized to perform. These attributes are compared to the information contained in a database for a given user and the result is returned to AAA to determine the user's actual capabilities and restrictions. The database can be located locally on the access server or router or it can be hosted remotely on a RADIUS or TACACS+ security server. Remote security servers, such as RADIUS and TACACS+, authorize users for specific rights by associating attribute-value (AV) pairs, which define those rights with the appropriate user. All authorization methods must be defined through AAA.

As with authentication, you configure AAA authorization by defining a named list of authorization methods, and then applying that list to various interfaces. For information about configuring authorization using AAA, refer to the chapter "Configuring Authorization."

- **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.

Accounting enables you to track the services users are accessing as well as the amount of network resources they are consuming. When AAA accounting is activated, the network access server reports user activity to the RADIUS or TACACS+ security server (depending on which security method you have implemented) in the form of accounting records. Each accounting record is comprised of accounting AV pairs and is stored on the access control server. This data can then be analyzed for network management, client billing, and/or auditing. All accounting methods must be defined through AAA. As with authentication and authorization, you configure AAA accounting by defining a named list of accounting methods, and then applying that list to various interfaces. For information about configuring accounting using AAA, refer to the chapter "Configuring Accounting."

In many circumstances, AAA uses protocols such as RADIUS, TACACS+, or Kerberos to administer its security functions. If your router or access server 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.

Although AAA is the primary (and recommended) method for access control, Cisco IOS software provides additional features for simple access control that are outside the scope of AAA, such as local username authentication, line password authentication, and enable password authentication. However, these features do not provide the same degree of access control that is possible by using AAA.

This section includes the following sections:

- [Benefits of Using AAA](#)
- [AAA Philosophy](#)
- [Method Lists](#)

Benefits of Using AAA

AAA provides the following benefits:

- Increased flexibility and control of access configuration
- Scalability
- Standardized authentication methods, such as RADIUS, TACACS+, and Kerberos
- Multiple backup systems

**Note**

The deprecated protocols, TACACS and extended TACACS, are not compatible with AAA; if you select these security protocols, you will not be able to take advantage of the AAA security services.

AAA Philosophy

AAA is designed to enable you to dynamically configure the type of authentication and authorization you want on a per-line (per-user) or per-service (for example, IP, IPX, or VPDN) basis. You define the type of authentication and authorization you want by creating method lists, then applying those method lists to specific services or interfaces.

For information about applications that use AAA, such as per-user configuration and virtual profiles, refer to the chapters “Configuring Per-User Configuration” and “Configuring Virtual Profiles” in the *Cisco IOS Dial Technologies Configuration Guide*, Release 12.2.

Method Lists

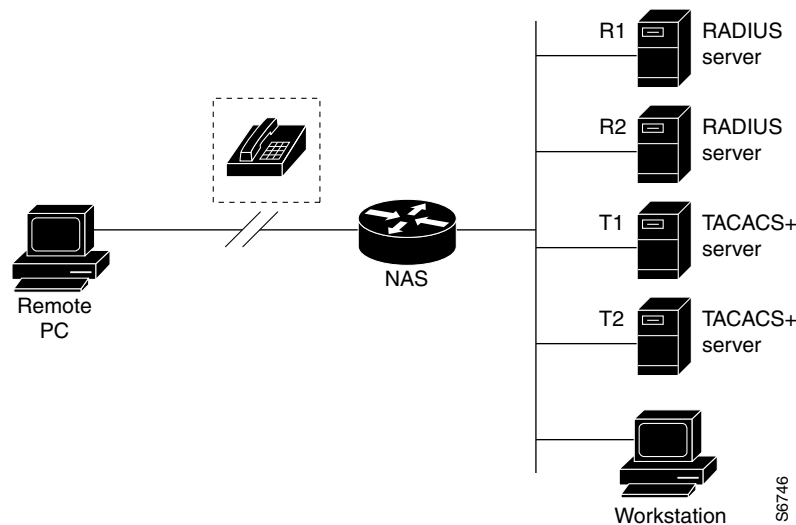
A method list is a sequential list that defines the authentication methods used to authenticate a user. Method lists enable you to designate one or more security protocols to be used for authentication, thus ensuring a backup system for authentication in case the initial method fails. Cisco IOS software uses the first method listed to authenticate users; if that method does not respond, Cisco IOS software selects the next authentication method in the method list. This process continues until there is successful communication with a listed authentication method or the authentication method list is exhausted, in which case authentication fails.

**Note**

Cisco IOS software attempts authentication with the next listed authentication method only when there is no response from the previous method. If authentication fails at any point in this cycle—meaning that the security server or local username database responds by denying the user access—the authentication process stops and no other authentication methods are attempted.

Figure 2 shows a typical AAA network configuration that includes four security servers: R1 and R2 are RADIUS servers, and T1 and T2 are TACACS+ servers.

Figure 2 Typical AAA Network Configuration



Suppose the system administrator has defined a method list where R1 will be contacted first for authentication information, then R2, T1, T2, and finally the local username database on the access server itself. When a remote user attempts to dial in to the network, the network access server first queries R1 for authentication information. If R1 authenticates the user, it issues a PASS response to the network access server and the user is allowed to access the network. If R1 returns a FAIL response, the user is denied access and the session is terminated. If R1 does not respond, then the network access server processes that as an ERROR and queries R2 for authentication information. This pattern continues through the remaining designated methods until the user is either authenticated or rejected, or until the session is terminated. If all of the authentication methods return errors, the network access server will process the session as a failure, and the session will be terminated.



Note

A FAIL response is significantly different from an ERROR. A FAIL means that the user has not met the criteria contained in the applicable authentication database to be successfully authenticated. Authentication ends with a FAIL response. An ERROR means that the security server has not responded to an authentication query. Because of this, no authentication has been attempted. Only when an ERROR is detected will AAA select the next authentication method defined in the authentication method list.

Where to Begin

You must first decide what kind of security solution you want to implement. You need to assess the security risks in your particular network and decide on the appropriate means to prevent unauthorized entry and attack. For more information about assessing your security risks and possible security solutions, refer to the chapter “Security Overview.” Cisco recommends that you use AAA, no matter how minor your security needs might be.

This section includes the following subsections:

- [Overview of the AAA Configuration Process](#)
- [Enabling AAA](#)
- [Disabling AAA](#)

Overview of the AAA Configuration Process

Configuring AAA is relatively simple after you understand the basic process involved. To configure security on a Cisco router or access server using AAA, follow this process:

1. Enable AAA by using the **aaa new-model** global configuration command.
2. If you decide to use a separate security server, configure security protocol parameters, such as RADIUS, TACACS+, or Kerberos.
3. Define the method lists for authentication by using an AAA authentication command.
4. Apply the method lists to a particular interface or line, if required.
5. (Optional) Configure authorization using the **aaa authorization** command.
6. (Optional) Configure accounting using the **aaa accounting** command.

For a complete description of the commands used in this chapter, refer to the chapter “Authentication Commands” of the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

Enabling AAA



Note

Before you can use any of the services AAA network security services provide, you must enable AAA.

When you enable AAA, you can no longer access the commands to configure the older protocols, TACACS or extended TACACS. If you decided to use TACACS or extended TACACS in your security solution, do not enable AAA.

To enable AAA, use the following command in global configuration mode:

Command	Purpose
Router (config)# aaa new-model	Enables AAA.

Disabling AAA

You can disable AAA functionality with a single command if you decide that your security needs cannot be met by AAA but can be met by using TACACS, extended TACACS, or a line security method that can be implemented without AAA. To disable AAA, use the following command in global configuration mode:

Command	Purpose
Router(config)# no aaa new-model	Disables AAA.

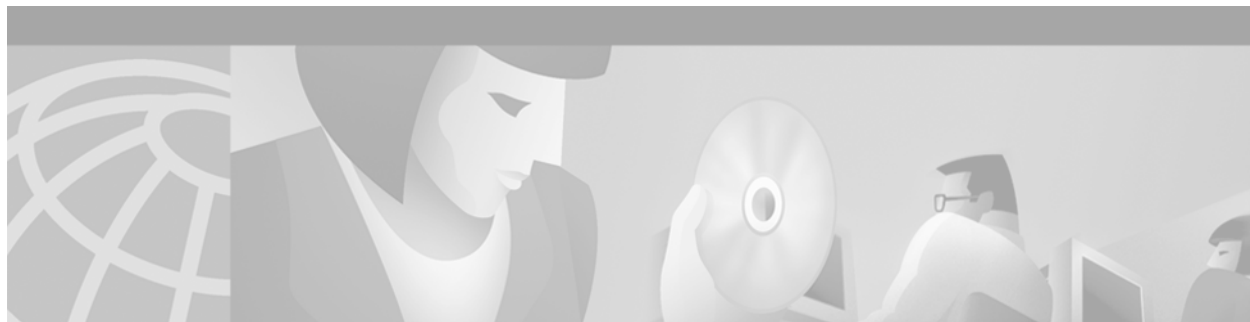
What to Do Next

Once you have enabled AAA, you are ready to configure the other elements relating to your selected security solution. [Table 3](#) describes AAA configuration tasks and where to find more information.

Table 3 **AAA Access Control Security Solutions Methods**

Task	Chapter in the <i>Cisco IOS Security Configuration Guide</i>
Configuring local login authentication	“Configuring Authentication”
Controlling login using security server authentication	“Configuring Authentication”
Defining method lists for authentication	“Configuring Authentication”
Applying method lists to a particular interface or line	“Configuring Authentication”
Configuring RADIUS security protocol parameters	“Configuring RADIUS”
Configuring TACACS+ security protocol parameters	“Configuring TACACS+”
Configuring Kerberos security protocol parameters	“Configuring Kerberos”
Enabling TACACS+ authorization	“Configuring Authorization”
Enabling RADIUS authorization	“Configuring Authorization”
Viewing supported IETF RADIUS attributes	“RADIUS Attributes” (Appendix)
Viewing supported vendor-specific RADIUS attributes	“RADIUS Attributes” (Appendix)
Viewing supported TACACS+ AV pairs	“TACACS+ AV Pairs” (Appendix)
Enabling accounting	“Configuring Accounting”

If you have elected not to use the AAA security services, see the “Configuring Authentication” chapter for the non-AAA configuration task “Configuring Login Authentication.”



Configuring Authentication

Authentication verifies users before they are allowed access to the network and network services. The Cisco IOS software implementation of authentication is divided into two main categories:

- [AAA Authentication Methods Configuration Task List](#)
- [Non-AAA Authentication Methods](#)

Authentication, for the most part, is implemented through the AAA security services. Cisco recommends that, whenever possible, AAA be used to implement authentication.

This chapter describes both AAA and non-AAA authentication methods. For authentication configuration examples, refer to the “[Authentication Examples](#)” section at the end of this chapter. For a complete description of the AAA commands used in this chapter, refer to the “Authentication, Authorization, and Accounting (AAA)” part of the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature, or refer to the software release notes for a specific release. For more information, see the section “Identifying Supported Platforms” in the chapter “Using Cisco IOS Software.”

In This Chapter

This chapter contains the following sections:

- [Named Method Lists for Authentication](#)
- [AAA Authentication Methods Configuration Task List](#)
- [Non-AAA Authentication Methods](#)
- [Authentication Examples](#)

Named Method Lists for Authentication

To configure AAA authentication, you must first define a named list of authentication methods, and then apply that list to various interfaces. The method list defines the types of authentication to be performed and the sequence in which they will be performed; it must be applied to a specific interface before any

of the defined authentication methods will be performed. The only exception is the default method list (which is named “default”). The default method list is automatically applied to all interfaces except those that have a named method list explicitly defined. A defined method list overrides the default method list.

A method list is a sequential list describing the authentication methods to be queried in order to authenticate a user. Method lists enable you to designate one or more security protocols to be used for authentication, thus ensuring a backup system for authentication in case the initial method fails. Cisco IOS software uses the first listed method to authenticate users. If that method fails to respond, the Cisco IOS software selects the next authentication method listed in the method list. This process continues until there is successful communication with a listed authentication method, or all methods defined in the method list are exhausted.

It is important to note that the Cisco IOS software attempts authentication with the next listed authentication method only when there is no response from the previous method. If authentication fails at any point in this cycle—meaning that the security server or local username database responds by denying the user access—the authentication process stops and no other authentication methods are attempted.

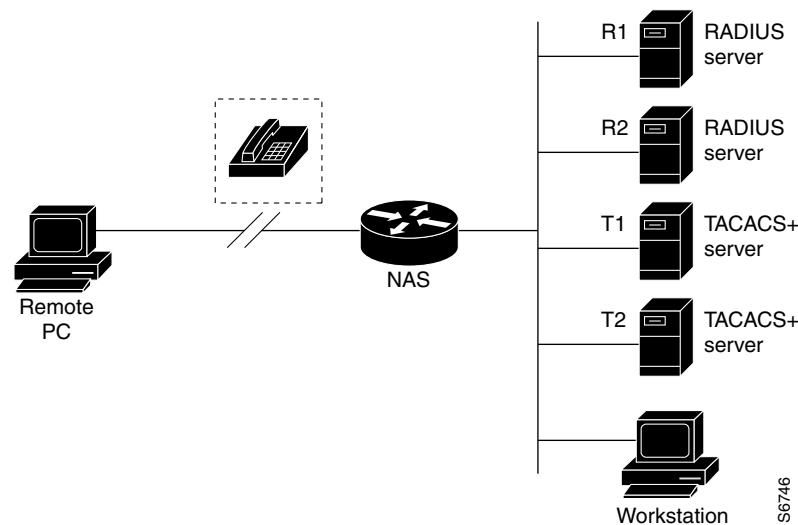
This section contains the following subsections:

- [Method Lists and Server Groups](#)
- [Method List Examples](#)
- [AAA Authentication General Configuration Procedure](#)

Method Lists and Server Groups

A server group is a way to group existing RADIUS or TACACS+ server hosts for use in method lists. [Figure 3](#) shows a typical AAA network configuration that includes four security servers: R1 and R2 are RADIUS servers and T1 and T2 are TACACS+ servers. R1 and R2 make up the group of RADIUS server. T1 and T2 make up the group of TACACS+ servers.

Figure 3 Typical AAA Network Configuration



Using server groups, you can specify a subset of the configured server hosts and use them for a particular service. For example, server groups allow you to define R1 and R2 as a server group, and define T1 and T2 as a separate server group. For example, you can specify R1 and T1 in the method list for authentication login, while specifying R2 and T2 in the method list for PPP authentication.

Server groups also can include multiple host entries for the same server, as long as each entry has a unique identifier. The combination of an IP address and a UDP port number creates a unique identifier, allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. In other words, this unique identifier enables RADIUS requests to be sent to different UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service—for example, authentication—the second host entry configured acts as failover backup to the first one. Using this example, if the first host entry fails to provide accounting services, the network access server will try the second host entry configured on the same device for accounting services. (The RADIUS host entries will be tried in the order in which they are configured.)

For more information about configuring server groups and about configuring server groups based on Dialed Number Identification Service (DNIS) numbers, refer to the “Configuring RADIUS” or “Configuring TACACS+” chapter.

Method List Examples

Suppose the system administrator has decided on a security solution where all interfaces will use the same authentication methods to authenticate PPP connections. In the RADIUS group, R1 is contacted first for authentication information, then if there is no response, R2 is contacted. If R2 does not respond, T1 in the TACACS+ group is contacted; if T1 does not respond, T2 is contacted. If all designated servers fail to respond, authentication falls to the local username database on the access server itself. To implement this solution, the system administrator would create a default method list by entering the following command:

```
aaa authentication ppp default group radius group tacacs+ local
```

In this example, “default” is the name of the method list. The protocols included in this method list are listed after the name, in the order they are to be queried. The default list is automatically applied to all interfaces.

When a remote user attempts to dial in to the network, the network access server first queries R1 for authentication information. If R1 authenticates the user, it issues a PASS response to the network access server and the user is allowed to access the network. If R1 returns a FAIL response, the user is denied access and the session is terminated. If R1 does not respond, then the network access server processes that as an ERROR and queries R2 for authentication information. This pattern would continue through the remaining designated methods until the user is either authenticated or rejected, or until the session is terminated.

It is important to remember that a FAIL response is significantly different from an ERROR. A FAIL means that the user has not met the criteria contained in the applicable authentication database to be successfully authenticated. Authentication ends with a FAIL response. An ERROR means that the security server has not responded to an authentication query. Because of this, no authentication has been attempted. Only when an ERROR is detected will AAA select the next authentication method defined in the authentication method list.

Suppose the system administrator wants to apply a method list only to a particular interface or set of interfaces. In this case, the system administrator creates a named method list and then applies this named list to the applicable interfaces. The following example shows how the system administrator can implement an authentication method that will be applied only to interface 3:

```
aaa authentication ppp default group radius group tacacs+ local
aaa authentication ppp apple group radius group tacacs+ local none
interface async 3
ppp authentication chap apple
```

In this example, “apple” is the name of the method list, and the protocols included in this method list are listed after the name in the order in which they are to be performed. After the method list has been created, it is applied to the appropriate interface. Note that the method list name (apple) in both the AAA and PPP authentication commands must match.

In the following example, the system administrator uses server groups to specify that only R2 and T2 are valid servers for PPP authentication. To do this, the administrator must define specific server groups whose members are R2 (172.16.2.7) and T2 (172.16.2.77), respectively. In this example, the RADIUS server group “rad2only” is defined as follows using the **aaa group server** command:

```
aaa group server radius rad2only
server 172.16.2.7
```

The TACACS+ server group “tac2only” is defined as follows using the **aaa group server** command:

```
aaa group server tacacs+ tac2only
server 172.16.2.77
```

The administrator then applies PPP authentication using the server groups. In this example, the default methods list for PPP authentication follows this order: **group rad2only**, **group tac2only**, and **local**:

```
aaa authentication ppp default group rad2only group tac2only local
```

AAA Authentication General Configuration Procedure

To configure AAA authentication, perform the following tasks:

1. Enable AAA by using the **aaa new-model** global configuration command. For more information about configuring AAA, refer to the chapter “AAA Overview”.
2. Configure security protocol parameters, such as RADIUS, TACACS+, or Kerberos if you are using a security server. For more information about RADIUS, refer to the chapter “Configuring RADIUS”. For more information about TACACS+, refer to the chapter “Configuring TACACS+”. For more information about Kerberos, refer to the chapter “Configuring Kerberos”.
3. Define the method lists for authentication by using an AAA authentication command.
4. Apply the method lists to a particular interface or line, if required.

AAA Authentication Methods Configuration Task List

This section discusses the following AAA authentication methods:

- [Configuring Login Authentication Using AAA](#)
- [Configuring PPP Authentication Using AAA](#)
- [Configuring AAA Scalability for PPP Requests](#)
- [Configuring ARAP Authentication Using AAA](#)

- [Configuring NASI Authentication Using AAA](#)
- [Specifying the Amount of Time for Login Input](#)
- [Enabling Password Protection at the Privileged Level](#)
- [Changing the Text Displayed at the Password Prompt](#)
- [Configuring Message Banners for AAA Authentication](#)
- [Configuring AAA Packet of Disconnect](#)
- [Enabling Double Authentication](#)
- [Enabling Automated Double Authentication](#)

**Note**

AAA features are not available for use until you enable AAA globally by issuing the **aaa new-model** command. For more information about enabling AAA, refer to the “AAA Overview” chapter.

For authentication configuration examples using the commands in this chapter, refer to the section “[Authentication Examples](#)” at the end of the this chapter.

Configuring Login Authentication Using AAA

The AAA security services facilitate a variety of login authentication methods. Use the **aaa authentication login** command to enable AAA authentication no matter which of the supported login authentication methods you decide to use. With the **aaa authentication login** command, you create one or more lists of authentication methods that are tried at login. These lists are applied using the **login authentication** line configuration command.

To configure login authentication by using AAA, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa new-model	Enables AAA globally.
Step 2	Router(config)# aaa authentication login {default list-name} method1 [method2...]	Creates a local authentication list.
Step 3	Router(config)# line [aux console tty vty] line-number [ending-line-number]	Enters line configuration mode for the lines to which you want to apply the authentication list.
Step 4	Router(config-line)# login authentication {default list-name}	Applies the authentication list to a line or set of lines.

The *list-name* is a character string used to name the list you are creating. The method argument refers to the actual method the authentication algorithm tries. The additional methods of authentication are used only if the previous method returns an error, not if it fails. To specify that the authentication should succeed even if all methods return an error, specify **none** as the final method in the command line.

For example, to specify that authentication should succeed even if (in this example) the TACACS+ server returns an error, enter the following command:

```
aaa authentication login default group tacacs+ none
```

**Note**

Because the **none** keyword enables *any* user logging in to successfully authenticate, it should be used only as a backup method of authentication.

To create a default list that is used when a named list is *not* specified in the **login authentication** command, use the **default** keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all interfaces.

For example, to specify RADIUS as the default method for user authentication during login, enter the following command:

```
aaa authentication login default group radius
```

Table 4 lists the supported login authentication methods.

Table 4 AAA Authentication Login Methods

Keyword	Description
enable	Uses the enable password for authentication.
krb5	Uses Kerberos 5 for authentication.
krb5-telnet	Uses Kerberos 5 Telnet authentication protocol when using Telnet to connect to the router. If selected, this keyword must be listed as the first method in the method list.
line	Uses the line password for authentication.
local	Uses the local username database for authentication.
local-case	Uses case-sensitive local username authentication.
none	Uses no authentication.
group radius	Uses the list of all RADIUS servers for authentication.
group tacacs+	Uses the list of all TACACS+ servers for authentication.
group group-name	Uses a subset of RADIUS or TACACS+ servers for authentication as defined by the aaa group server radius or aaa group server tacacs+ command.



Note

The **login** command only changes username and privilege level but does not execute a shell; therefore autocommands will not be executed. To execute autocommands under this circumstance, you need to establish a Telnet session back into the router (loop-back). Make sure that the router has been configured for secure Telnet sessions if you choose to implement autocommands this way.

This section includes the following sections:

- [Login Authentication Using Enable Password](#)
- [Login Authentication Using Kerberos](#)
- [Login Authentication Using Line Password](#)
- [Login Authentication Using Local Password](#)
- [Login Authentication Using Group RADIUS](#)
- [Login Authentication Using Group TACACS+](#)
- [Login Authentication Using group group-name](#)

Login Authentication Using Enable Password

Use the **aaa authentication login** command with the **enable method** keyword to specify the enable password as the login authentication method. For example, to specify the enable password as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication login default enable
```

Before you can use the enable password as the login authentication method, you need to define the enable password. For more information about defining enable passwords, refer to the chapter “Configuring Passwords and Privileges.”

Login Authentication Using Kerberos

Authentication via Kerberos is different from most other authentication methods: the user’s password is never sent to the remote access server. Remote users logging in to the network are prompted for a username. If the key distribution center (KDC) has an entry for that user, it creates an encrypted ticket granting ticket (TGT) with the password for that user and sends it back to the router. The user is then prompted for a password, and the router attempts to decrypt the TGT with that password. If it succeeds, the user is authenticated and the TGT is stored in the user’s credential cache on the router.

While **krb5** does use the KINIT program, a user does not need to run the KINIT program to get a TGT to authenticate to the router. This is because KINIT has been integrated into the login procedure in the Cisco IOS implementation of Kerberos.

Use the **aaa authentication login** command with the **krb5 method** keyword to specify Kerberos as the login authentication method. For example, to specify Kerberos as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication login default krb5
```

Before you can use Kerberos as the login authentication method, you need to enable communication with the Kerberos security server. For more information about establishing communication with a Kerberos server, refer to the chapter “Configuring Kerberos.”

Login Authentication Using Line Password

Use the **aaa authentication login** command with the **line method** keyword to specify the line password as the login authentication method. For example, to specify the line password as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication login default line
```

Before you can use a line password as the login authentication method, you need to define a line password. For more information about defining line passwords, refer to the section “[Configuring Line Password Protection](#)” in this chapter.

Login Authentication Using Local Password

Use the **aaa authentication login** command with the **local method** keyword to specify that the Cisco router or access server will use the local username database for authentication. For example, to specify the local username database as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication login default local
```

For information about adding users into the local username database, refer to the section “[Establishing Username Authentication](#)” in this chapter.

Login Authentication Using Group RADIUS

Use the **aaa authentication login** command with the **group radius** *method* to specify RADIUS as the login authentication method. For example, to specify RADIUS as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication login default group radius
```

Before you can use RADIUS as the login authentication method, you need to enable communication with the RADIUS security server. For more information about establishing communication with a RADIUS server, refer to the chapter “Configuring RADIUS.”

Configuring RADIUS Attribute 8 in Access Requests

Once you have used the **aaa authentication login** command to specify RADIUS and your login host has been configured to request its IP address from the NAS, you can send attribute 8 (Framed-IP-Address) in access-request packets by using the **radius-server attribute 8 include-in-access-req** command in global configuration mode. This command makes it possible for a NAS to provide the RADIUS server with a hint of the user IP address in advance of user authentication. For more information about attribute 8, refer to the appendix “RADIUS Attributes” at the end of the book.

Login Authentication Using Group TACACS+

Use the **aaa authentication login** command with the **group tacacs+** *method* to specify TACACS+ as the login authentication method. For example, to specify TACACS+ as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication login default group tacacs+
```

Before you can use TACACS+ as the login authentication method, you need to enable communication with the TACACS+ security server. For more information about establishing communication with a TACACS+ server, refer to the chapter “Configuring TACACS+.”

Login Authentication Using group group-name

Use the **aaa authentication login** command with the **group group-name** *method* to specify a subset of RADIUS or TACACS+ servers to use as the login authentication method. To specify and define the group name and the members of the group, use the **aaa group server** command. For example, use the **aaa group server** command to first define the members of **group loginrad**:

```
aaa group server radius loginrad
server 172.16.2.3
server 172.16.2.17
server 172.16.2.32
```

This command specifies RADIUS servers 172.16.2.3, 172.16.2.17, and 172.16.2.32 as members of the group *loginrad*.

To specify **group loginrad** as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication login default group loginrad
```

Before you can use a group name as the login authentication method, you need to enable communication with the RADIUS or TACACS+ security server. For more information about establishing communication with a RADIUS server, refer to the chapter “Configuring RADIUS.” For more information about establishing communication with a TACACS+ server, refer to the chapter “Configuring TACACS+.”

Configuring PPP Authentication Using AAA

Many users access network access servers through dialup via async or ISDN. Dialup via async or ISDN bypasses the CLI completely; instead, a network protocol (such as PPP or ARA) starts as soon as the connection is established.

The AAA security services facilitate a variety of authentication methods for use on serial interfaces running PPP. Use the **aaa authentication ppp** command to enable AAA authentication no matter which of the supported PPP authentication methods you decide to use.

To configure AAA authentication methods for serial lines using PPP, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa new-model	Enables AAA globally.
Step 2	Router(config)# aaa authentication ppp {default list-name} method1 [method2...]	Creates a local authentication list.
Step 3	Router(config)# interface interface-type interface-number	Enters interface configuration mode for the interface to which you want to apply the authentication list.
Step 4	Router(config-if)# ppp authentication {protocol1 [protocol2...]} [if-needed] [default list-name] [callin] [one-time] [optional]	Applies the authentication list to a line or set of lines. In this command, <i>protocol1</i> and <i>protocol2</i> represent the following protocols: CHAP, MS-CHAP, and PAP. PPP authentication is attempted first using the first authentication method, specified by <i>protocol1</i> . If <i>protocol1</i> is unable to establish authentication, the next configured protocol is used to negotiate authentication.

With the **aaa authentication ppp** command, you create one or more lists of authentication methods that are tried when a user tries to authenticate via PPP. These lists are applied using the **ppp authentication** line configuration command.

To create a default list that is used when a named list is *not* specified in the **ppp authentication** command, use the **default** keyword followed by the methods you want used in default situations.

For example, to specify the local username database as the default method for user authentication, enter the following command:

```
aaa authentication ppp default local
```

The *list-name* is any character string used to name the list you are creating. The method argument refers to the actual method the authentication algorithm tries. The additional methods of authentication are used only if the previous method returns an error, not if it fails. To specify that the authentication should succeed even if all methods return an error, specify **none** as the final method in the command line.

For example, to specify that authentication should succeed even if (in this example) the TACACS+ server returns an error, enter the following command:

```
aaa authentication ppp default group tacacs+ none
```



Note

Because **none** allows all users logging in to authenticate successfully, it should be used as a backup method of authentication.

Table 5 lists the supported login authentication methods.

Table 5 **AAA Authentication PPP Methods**

Keyword	Description
if-needed	Does not authenticate if user has already been authenticated on a TTY line.
krb5	Uses Kerberos 5 for authentication (can only be used for PAP authentication).
local	Uses the local username database for authentication.
local-case	Uses case-sensitive local username authentication.
none	Uses no authentication.
group radius	Uses the list of all RADIUS servers for authentication.
group tacacs+	Uses the list of all TACACS+ servers for authentication.
group <i>group-name</i>	Uses a subset of RADIUS or TACACS+ servers for authentication as defined by the aaa group server radius or aaa group server tacacs+ command.

This section includes the following sections:

- [PPP Authentication Using Kerberos](#)
- [PPP Authentication Using Local Password](#)
- [PPP Authentication Using Group RADIUS](#)
- [PPP Authentication Using Group TACACS+](#)
- [PPP Authentication Using group group-name](#)

PPP Authentication Using Kerberos

Use the **aaa authentication ppp** command with the **krb5** *method* keyword to specify Kerberos as the authentication method for use on interfaces running PPP. For example, to specify Kerberos as the method of user authentication when no other method list has been defined, enter the following command:

```
aaa authentication ppp default krb5
```

Before you can use Kerberos as the PPP authentication method, you need to enable communication with the Kerberos security server. For more information about establishing communication with a Kerberos server, refer to the chapter “Configuring Kerberos”.



Note

Kerberos login authentication works only with PPP PAP authentication.

PPP Authentication Using Local Password

Use the **aaa authentication ppp** command with the *method* keyword **local** to specify that the Cisco router or access server will use the local username database for authentication. For example, to specify the local username database as the method of authentication for use on lines running PPP when no other method list has been defined, enter the following command:

```
aaa authentication ppp default local
```

For information about adding users into the local username database, refer to the section “[Establishing Username Authentication](#)” in this chapter.

PPP Authentication Using Group RADIUS

Use the **aaa authentication ppp** command with the **group radius method** to specify RADIUS as the login authentication method. For example, to specify RADIUS as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication ppp default group radius
```

Before you can use RADIUS as the PPP authentication method, you need to enable communication with the RADIUS security server. For more information about establishing communication with a RADIUS server, refer to the chapter “Configuring RADIUS.”

Configuring RADIUS Attribute 44 in Access Requests

Once you have used the **aaa authentication ppp** command with the **group radius method** to specify RADIUS as the login authentication method, you can configure your router to send attribute 44 (Acct-Session-ID) in access-request packets by using the **radius-server attribute 44 include-in-access-req** command in global configuration mode. This command allows the RADIUS daemon to track a call from the beginning of the call to the end of the call. For more information on attribute 44, refer to the appendix “RADIUS Attributes” at the end of the book.

PPP Authentication Using Group TACACS+

Use the **aaa authentication ppp** command with the **group tacacs+ method** to specify TACACS+ as the login authentication method. For example, to specify TACACS+ as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication ppp default group tacacs+
```

Before you can use TACACS+ as the PPP authentication method, you need to enable communication with the TACACS+ security server. For more information about establishing communication with a TACACS+ server, refer to the chapter “Configuring TACACS+.”

PPP Authentication Using group group-name

Use the **aaa authentication ppp** command with the **group group-name method** to specify a subset of RADIUS or TACACS+ servers to use as the login authentication method. To specify and define the group name and the members of the group, use the **aaa group server** command. For example, use the **aaa group server** command to first define the members of **group ppprad**:

```
aaa group server radius ppprad
server 172.16.2.3
server 172.16.2.17
server 172.16.2.32
```

This command specifies RADIUS servers 172.16.2.3, 172.16.2.17, and 172.16.2.32 as members of the group *ppprad*.

To specify **group ppprad** as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication ppp default group ppprad
```

Before you can use a group name as the PPP authentication method, you need to enable communication with the RADIUS or TACACS+ security server. For more information about establishing communication with a RADIUS server, refer to the chapter “Configuring RADIUS”. For more information about establishing communication with a TACACS+ server, refer to the chapter “Configuring TACACS+.”

Configuring AAA Scalability for PPP Requests

You can configure and monitor the number of background processes allocated by the PPP manager in the network access server (NAS) to deal with AAA authentication and authorization requests. In previous Cisco IOS releases, only one background process was allocated to handle all AAA requests for PPP. This meant that parallelism in AAA servers could not be fully exploited. The AAA Scalability feature enables you to configure the number of processes used to handle AAA requests for PPP, thus increasing the number of users that can be simultaneously authenticated or authorized.

To allocate a specific number of background processes to handle AAA requests for PPP, use the following command in global configuration mode:

Command	Purpose
Router(config)# aaa processes <i>number</i>	Allocates a specific number of background processes to handle AAA authentication and authorization requests for PPP.

The argument *number* defines the number of background processes earmarked to process AAA authentication and authorization requests for PPP and can be configured for any value from 1 to 2147483647. Because of the way the PPP manager handles requests for PPP, this argument also defines the number of new users that can be simultaneously authenticated. This argument can be increased or decreased at any time.



Note

Allocating additional background processes can be expensive. You should configure the minimum number of background processes capable of handling the AAA requests for PPP.

Configuring ARAP Authentication Using AAA

With the **aaa authentication arap** command, you create one or more lists of authentication methods that are tried when AppleTalk Remote Access Protocol (ARAP) users attempt to log in to the router. These lists are used with the **arap authentication** line configuration command.

Use the following commands starting in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa new-model	Enables AAA globally.
Step 2	Router(config)# aaa authentication arap { default <i>list-name</i> } <i>method1</i> [<i>method2...</i>]	Enables authentication for ARAP users.
Step 3	Router(config)# line <i>number</i>	(Optional) Changes to line configuration mode.
Step 4	Router(config-line)# autoselect arap	(Optional) Enables autoselection of ARAP.
Step 5	Router(config-line)# autoselect during-login	(Optional) Starts the ARAP session automatically at user login.
Step 6	Router(config-line)# arap authentication <i>list-name</i>	(Optional—not needed if default is used in the aaa authentication arap command) Enables TACACS+ authentication for ARAP on a line.

The *list-name* is any character string used to name the list you are creating. The method argument refers to the actual list of methods the authentication algorithm tries, in the sequence entered.

To create a default list that is used when a named list is *not* specified in the **arap authentication** command, use the **default** keyword followed by the methods you want to be used in default situations.

The additional methods of authentication are used only if the previous method returns an error, not if it fails. To specify that the authentication should succeed even if all methods return an error, specify **none** as the final method in the command line.

**Note**

Because **none** allows all users logging in to authenticate successfully, it should be used as a backup method of authentication.

Table 6 lists the supported login authentication methods.

Table 6 AAA Authentication ARAP Methods

Keyword	Description
auth-guest	Allows guest logins only if the user has already logged in to EXEC.
guest	Allows guest logins.
line	Uses the line password for authentication.
local	Uses the local username database for authentication.
local-case	Uses case-sensitive local username authentication.
group radius	Uses the list of all RADIUS servers for authentication.
group tacacs+	Uses the list of all TACACS+ servers for authentication.
group <i>group-name</i>	Uses a subset of RADIUS or TACACS+ servers for authentication as defined by the aaa group server radius or aaa group server tacacs+ command.

For example, to create a default AAA authentication method list used with ARAP, enter the following command:

```
aaa authentication arap default if-needed none
```

To create the same authentication method list for ARAP but name the list *MIS-access*, enter the following command:

```
aaa authentication arap MIS-access if-needed none
```

This section includes the following sections:

- [ARAP Authentication Allowing Authorized Guest Logins](#)
- [ARAP Authentication Allowing Guest Logins](#)
- [ARAP Authentication Using Line Password](#)
- [ARAP Authentication Using Local Password](#)
- [ARAP Authentication Using Group RADIUS](#)
- [ARAP Authentication Using Group TACACS+](#)
- [ARAP Authentication Using Group group-name](#)

ARAP Authentication Allowing Authorized Guest Logins

Use the **aaa authentication arap** command with the **auth-guest** keyword to allow guest logins only if the user has already successfully logged in to the EXEC. This method must be the first listed in the ARAP authentication method list but it can be followed by other methods if it does not succeed. For example, to allow all authorized guest logins—meaning logins by users who have already successfully logged in to the EXEC—as the default method of authentication, using RADIUS only if that method fails, enter the following command:

```
aaa authentication arap default auth-guest group radius
```

For more information about ARAP authorized guest logins, refer to the chapter “Configuring AppleTalk” in the *Cisco IOS AppleTalk and Novell IPX Configuration Guide*.



Note

By default, guest logins through ARAP are disabled when you initialize AAA. To allow guest logins, you must use the **aaa authentication arap** command with either the **guest** or the **auth-guest** keyword.

ARAP Authentication Allowing Guest Logins

Use the **aaa authentication arap** command with the **guest** keyword to allow guest logins. This method must be the first listed in the ARAP authentication method list but it can be followed by other methods if it does not succeed. For example, to allow all guest logins as the default method of authentication, using RADIUS only if that method fails, enter the following command:

```
aaa authentication arap default guest group radius
```

For more information about ARAP guest logins, refer to the chapter “Configuring AppleTalk” in the *Cisco IOS AppleTalk and Novell IPX Configuration Guide*.

ARAP Authentication Using Line Password

Use the **aaa authentication arap** command with the *method* keyword **line** to specify the line password as the authentication method. For example, to specify the line password as the method of ARAP user authentication when no other method list has been defined, enter the following command:

```
aaa authentication arap default line
```

Before you can use a line password as the ARAP authentication method, you need to define a line password. For more information about defining line passwords, refer to the section “[Configuring Line Password Protection](#)” in this chapter.

ARAP Authentication Using Local Password

Use the **aaa authentication arap** command with the *method* keyword **local** to specify that the Cisco router or access server will use the local username database for authentication. For example, to specify the local username database as the method of ARAP user authentication when no other method list has been defined, enter the following command:

```
aaa authentication arap default local
```

For information about adding users to the local username database, refer to the section “[Establishing Username Authentication](#)” in this chapter.

ARAP Authentication Using Group RADIUS

Use the **aaa authentication arap** command with the **group radius** *method* to specify RADIUS as the ARAP authentication method. For example, to specify RADIUS as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication arap default group radius
```

Before you can use RADIUS as the ARAP authentication method, you need to enable communication with the RADIUS security server. For more information about establishing communication with a RADIUS server, refer to the chapter “Configuring RADIUS.”

ARAP Authentication Using Group TACACS+

Use the **aaa authentication arap** command with the **group tacacs+** *method* to specify TACACS+ as the ARAP authentication method. For example, to specify TACACS+ as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication arap default group tacacs+
```

Before you can use TACACS+ as the ARAP authentication method, you need to enable communication with the TACACS+ security server. For more information about establishing communication with a TACACS+ server, refer to the chapter “Configuring TACACS+.”

ARAP Authentication Using Group group-name

Use the **aaa authentication arap** command with the **group group-name** *method* to specify a subset of RADIUS or TACACS+ servers to use as the ARAP authentication method. To specify and define the group name and the members of the group, use the **aaa group server** command. For example, use the **aaa group server** command to first define the members of **group araprad**:

```
aaa group server radius araprad
server 172.16.2.3
server 172.16.2.17
server 172.16.2.32
```

This command specifies RADIUS servers 172.16.2.3, 172.16.2.17, and 172.16.2.32 as members of the group *araprad*.

To specify **group araprad** as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication arap default group araprad
```

Before you can use a group name as the ARAP authentication method, you need to enable communication with the RADIUS or TACACS+ security server. For more information about establishing communication with a RADIUS server, refer to the chapter “Configuring RADIUS.” For more information about establishing communication with a TACACS+ server, refer to the chapter “Configuring TACACS+.”

Configuring NASI Authentication Using AAA

With the **aaa authentication nasi** command, you create one or more lists of authentication methods that are tried when NetWare Asynchronous Services Interface (NASI) users attempt to log in to the router. These lists are used with the **nasi authentication** line configuration command.

To configure NASI authentication using AAA, use the following commands starting in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa new-model	Enables AAA globally.
Step 2	Router(config)# aaa authentication nasi { default <i>list-name</i> } <i>method1</i> [<i>method2...</i>]	Enables authentication for NASI users.
Step 3	Router(config)# line <i>number</i>	(Optional—not needed if default is used in the aaa authentication nasi command) Enters line configuration mode.
Step 4	Router(config-line)# nasi authentication <i>list-name</i>	(Optional—not needed if default is used in the aaa authentication nasi command) Enables authentication for NASI on a line.

The *list-name* is any character string used to name the list you are creating. The method argument refers to the actual list of methods the authentication algorithm tries, in the sequence entered.

To create a default list that is used when a named list is *not* specified in the **aaa authentication nasi** command, use the **default** keyword followed by the methods you want to be used in default situations.

The additional methods of authentication are used only if the previous method returns an error, not if it fails. To specify that the authentication should succeed even if all methods return an error, specify **none** as the final method in the command line.



Note

Because **none** allows all users logging in to authenticate successfully, it should be used as a backup method of authentication.

Table 7 lists the supported NASI authentication methods.

Table 7 AAA Authentication NASI Methods

Keyword	Description
enable	Uses the enable password for authentication.
line	Uses the line password for authentication.
local	Uses the local username database for authentication.
local-case	Uses case-sensitive local username authentication.
none	Uses no authentication.
group radius	Uses the list of all RADIUS servers for authentication.
group tacacs+	Uses the list of all TACACS+ servers for authentication.
group <i>group-name</i>	Uses a subset of RADIUS or TACACS+ servers for authentication as defined by the aaa group server radius or aaa group server tacacs+ command.

This section includes the following sections:

- [NASI Authentication Using Enable Password](#)
- [NASI Authentication Using Line Password](#)
- [NASI Authentication Using Local Password](#)
- [NASI Authentication Using Group RADIUS](#)
- [NASI Authentication Using Group TACACS+](#)
- [NASI Authentication Using group group-name](#)

NASI Authentication Using Enable Password

Use the **aaa authentication nasi** command with the *method* keyword **enable** to specify the enable password as the authentication method. For example, to specify the enable password as the method of NASI user authentication when no other method list has been defined, enter the following command:

```
aaa authentication nasi default enable
```

Before you can use the enable password as the authentication method, you need to define the enable password. For more information about defining enable passwords, refer to the chapter “Configuring Passwords and Privileges.”

NASI Authentication Using Line Password

Use the **aaa authentication nasi** command with the *method* keyword **line** to specify the line password as the authentication method. For example, to specify the line password as the method of NASI user authentication when no other method list has been defined, enter the following command:

```
aaa authentication nasi default line
```

Before you can use a line password as the NASI authentication method, you need to define a line password. For more information about defining line passwords, refer to the section “[Configuring Line Password Protection](#)” in this chapter.

NASI Authentication Using Local Password

Use the **aaa authentication nasi** command with the *method* keyword **local** to specify that the Cisco router or access server will use the local username database for authentication information. For example, to specify the local username database as the method of NASI user authentication when no other method list has been defined, enter the following command:

```
aaa authentication nasi default local
```

For information about adding users to the local username database, refer to the section “[Establishing Username Authentication](#)” in this chapter.

NASI Authentication Using Group RADIUS

Use the **aaa authentication nasi** command with the **group radius** *method* to specify RADIUS as the NASI authentication method. For example, to specify RADIUS as the method of NASI user authentication when no other method list has been defined, enter the following command:

```
aaa authentication nasi default group radius
```

Before you can use RADIUS as the NASI authentication method, you need to enable communication with the RADIUS security server. For more information about establishing communication with a RADIUS server, refer to the chapter “Configuring RADIUS.”

NASI Authentication Using Group TACACS+

Use the **aaa authentication nasi** command with the **group tacacs+** *method* keyword to specify TACACS+ as the NASI authentication method. For example, to specify TACACS+ as the method of NASI user authentication when no other method list has been defined, enter the following command:

```
aaa authentication nasi default group tacacs+
```

Before you can use TACACS+ as the authentication method, you need to enable communication with the TACACS+ security server. For more information about establishing communication with a TACACS+ server, refer to the chapter “Configuring TACACS+.”

NASI Authentication Using group group-name

Use the **aaa authentication nasi** command with the **group group-name** *method* to specify a subset of RADIUS or TACACS+ servers to use as the NASI authentication method. To specify and define the group name and the members of the group, use the **aaa group server** command. For example, use the **aaa group server** command to first define the members of **group nasirad**:

```
aaa group server radius nasirad
server 172.16.2.3
server 172.16.2.17
server 172.16.2.32
```

This command specifies RADIUS servers 172.16.2.3, 172.16.2.17, and 172.16.2.32 as members of the group *nasirad*.

To specify **group nasirad** as the method of user authentication at login when no other method list has been defined, enter the following command:

```
aaa authentication nasi default group nasirad
```

Before you can use a group name as the NASI authentication method, you need to enable communication with the RADIUS or TACACS+ security server. For more information about establishing communication with a RADIUS server, refer to the chapter “Configuring RADIUS”. For more information about establishing communication with a TACACS+ server, refer to the chapter “Configuring TACACS+.”

Specifying the Amount of Time for Login Input

The **timeout login response** command allows you to specify how long the system will wait for login input (such as username and password) before timing out. The default login value is 30 seconds; with the **timeout login response** command, you can specify a timeout value from 1 to 300 seconds. To change the login timeout value from the default of 30 seconds, use the following command in line configuration mode:

Command	Purpose
Router(config-line)# timeout login response <i>seconds</i>	Specifies how long the system will wait for login information before timing out.

Enabling Password Protection at the Privileged Level

Use the **aaa authentication enable default** command to create a series of authentication methods that are used to determine whether a user can access the privileged EXEC command level. You can specify up to four authentication methods. The additional methods of authentication are used only if the previous method returns an error, not if it fails. To specify that the authentication should succeed even if all methods return an error, specify **none** as the final method in the command line.

Use the following command in global configuration mode:

Command	Purpose
Router(config)# aaa authentication enable default <i>method1 [method2...]</i>	Enables user ID and password checking for users requesting privileged EXEC level. Note All aaa authentication enable default requests sent by the router to a RADIUS server include the username “\$enab15\$.” Requests sent to a TACACS+ server will include the username that is entered for login authentication.

The method argument refers to the actual list of methods the authentication algorithm tries, in the sequence entered. [Table 8](#) lists the supported enable authentication methods.

Table 8 AAA Authentication Enable Default Methods

Keyword	Description
enable	Uses the enable password for authentication.
line	Uses the line password for authentication.
none	Uses no authentication.
group radius	Uses the list of all RADIUS hosts for authentication. Note The RADIUS method does not work on a per-username basis.
group tacacs+	Uses the list of all TACACS+ hosts for authentication.
group <i>group-name</i>	Uses a subset of RADIUS or TACACS+ servers for authentication as defined by the aaa group server radius or aaa group server tacacs+ command.

Changing the Text Displayed at the Password Prompt

Use the **aaa authentication password-prompt** command to change the default text that the Cisco IOS software displays when prompting a user to enter a password. This command changes the password prompt for the enable password as well as for login passwords that are not supplied by remote security servers. The **no** form of this command returns the password prompt to the following default value:

Password:

The **aaa authentication password-prompt** command does not change any dialog that is supplied by a remote TACACS+ or RADIUS server.

The **aaa authentication password-prompt** command works when RADIUS is used as the login method. You will be able to see the password prompt defined in the command shown even when the RADIUS server is unreachable. The **aaa authentication password-prompt** command does not work with TACACS+. TACACS+ supplies the NAS with the password prompt to display to the users. If the TACACS+ server is reachable, the NAS gets the password prompt from the server and uses that prompt instead of the one defined in the **aaa authentication password-prompt** command. If the TACACS+ server is not reachable, the password prompt defined in the **aaa authentication password-prompt** command may be used.

Use the following command in global configuration mode:

Command	Purpose
Router(config)# aaa authentication password-prompt <i>text-string</i>	Changes the default text displayed when a user is prompted to enter a password.

Configuring Message Banners for AAA Authentication

AAA supports the use of configurable, personalized login and failed-login banners. You can configure message banners that will be displayed when a user logs in to the system to be authenticated using AAA and when, for whatever reason, authentication fails.

This section includes the following sections:

- [Configuring a Login Banner](#)
- [Configuring a Failed-Login Banner](#)

Configuring a Login Banner

To create a login banner, you need to configure a delimiting character, which notifies the system that the following text string is to be displayed as the banner, and then the text string itself. The delimiting character is repeated at the end of the text string to signify the end of the banner. The delimiting character can be any single character in the extended ASCII character set, but once defined as the delimiter, that character cannot be used in the text string making up the banner.

To configure a banner that will be displayed whenever a user logs in (replacing the default message for login), use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa new-model	Enables AAA.
Step 2	Router(config)# aaa authentication banner <i>delimiter string delimiter</i>	Creates a personalized login banner.

The maximum number of characters that can be displayed in the login banner is 2996 characters.

Configuring a Failed-Login Banner

To create a failed-login banner, you need to configure a delimiting character, which notifies the system that the following text string is to be displayed as the banner, and then the text string itself. The delimiting character is repeated at the end of the text string to signify the end of the failed-login banner. The delimiting character can be any single character in the extended ASCII character set, but once defined as the delimiter, that character cannot be used in the text string making up the banner.

To configure a message that will be displayed whenever a user fails login (replacing the default message for failed login), use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa new-model	Enables AAA.
Step 2	Router(config)# aaa authentication fail-message <i>delimiter string delimiter</i>	Creates a message to be displayed when a user fails login.

The maximum number of characters that can be displayed in the failed-login banner is 2996 characters.

Configuring AAA Packet of Disconnect

Packet of disconnect (POD) terminates connections on the network access server (NAS) when particular session attributes are identified. By using session information obtained from AAA, the POD client residing on a UNIX workstation sends disconnect packets to the POD server running on the network access server. The NAS terminates any inbound user session with one or more matching key attributes. It rejects requests when required fields are missing or when an exact match is not found.

To configure POD, perform the following tasks in global configuration mode:

	Command	Purpose
Step 1	Router(config) # aaa accounting network default start-stop radius	Enables AAA accounting records.
Step 2	Router(config) # aaa accounting delay-start	(Optional) Delays generation of the start accounting record until the Framed-IP-Address is assigned, allowing its use in the POD packet.
Step 3	Router(config) # aaa pod server server-key string	Enables POD reception.
Step 4	Router(config) # radius-server host IP address non-standard	Declares a RADIUS host that uses a vendor-proprietary version of RADIUS.

Enabling Double Authentication

Previously, PPP sessions could only be authenticated by using a single authentication method: either PAP or CHAP. Double authentication requires remote users to pass a second stage of authentication—after CHAP or PAP authentication—before gaining network access.

This second (“double”) authentication requires a password that is known to the user but *not* stored on the user’s remote host. Therefore, the second authentication is specific to a user, not to a host. This provides an additional level of security that will be effective even if information from the remote host is stolen. In addition, this also provides greater flexibility by allowing customized network privileges for each user.

The second stage authentication can use one-time passwords such as token card passwords, which are not supported by CHAP. If one-time passwords are used, a stolen user password is of no use to the perpetrator.

This section includes the following subsections:

- [How Double Authentication Works](#)
- [Configuring Double Authentication](#)
- [Accessing the User Profile After Double Authentication](#)

How Double Authentication Works

With double authentication, there are two authentication/authorization stages. These two stages occur after a remote user dials in and a PPP session is initiated.

In the first stage, the user logs in using the remote host name; CHAP (or PAP) authenticates the remote host, and then PPP negotiates with AAA to authorize the remote host. In this process, the network access privileges associated with the remote host are assigned to the user.

**Note**

We suggest that the network administrator restrict authorization at this first stage to allow only Telnet connections to the local host.

In the second stage, the remote user must Telnet to the network access server to be authenticated. When the remote user logs in, the user must be authenticated with AAA login authentication. The user then must enter the **access-profile** command to be reauthorized using AAA. When this authorization is complete, the user has been double authenticated, and can access the network according to per-user network privileges.

The system administrator determines what network privileges remote users will have after each stage of authentication by configuring appropriate parameters on a security server. To use double authentication, the user must activate it by issuing the **access-profile** command.

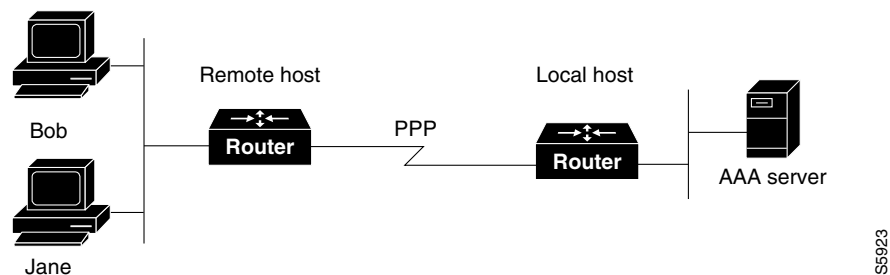
**Caution**

Double authentication can cause certain undesirable events if multiple hosts share a PPP connection to a network access server, as shown in [Figure 4](#).

First, if a user, Bob, initiates a PPP session and activates double authentication at the network access server (per [Figure 4](#)), any other user will automatically have the same network privileges as Bob until Bob's PPP session expires. This happens because Bob's authorization profile is applied to the network access server's interface during the PPP session and any PPP traffic from other users will use the PPP session Bob established.

Second, if Bob initiates a PPP session and activates double authentication, and then—before Bob's PPP session has expired—another user, Jane, executes the **access-profile** command (or, if Jane Telnets to the network access server and **autocommand access-profile** is executed), a reauthorization will occur and Jane's authorization profile will be applied to the interface—replacing Bob's profile. This can disrupt or halt Bob's PPP traffic, or grant Bob additional authorization privileges Bob should not have.

Figure 4 *Possibly Risky Topology: Multiple Hosts Share a PPP Connection to a Network Access Server*



Configuring Double Authentication

To configure double authentication, you must complete the following steps:

1. Enable AAA by using the **aaa-new model** global configuration command. For more information about enabling AAA, refer to the chapter “AAA Overview.”
2. Use the **aaa authentication** command to configure your network access server to use login and PPP authentication method lists, then apply those method lists to the appropriate lines or interfaces.

3. Use the **aaa authorization** command to configure AAA network authorization at login. For more information about configuring network authorization, refer to the “Configuring Authorization” chapter.
4. Configure security protocol parameters (for example, RADIUS or TACACS+). For more information about RADIUS, refer to the chapter “Configuring RADIUS”. For more information about TACACS+, refer to the chapter “Configuring TACACS+.”
5. Use access control list AV pairs on the security server that the user can connect to the local host only by establishing a Telnet connection.
6. (Optional) Configure the **access-profile** command as an autocommand. If you configure the autocommand, remote users will not have to manually enter the **access-profile** command to access authorized rights associated with their personal user profile. To learn about configuring autocommands, refer to the **autocommand** command in the *Cisco IOS Dial Technologies Command Reference: Network Services*.

**Note**

If the **access-profile** command is configured as an autocommand, users will still have to Telnet to the local host and log in to complete double authentication.

Follow these rules when creating the user-specific authorization statements (These rules relate to the default behavior of the **access-profile** command):

- Use valid AV pairs when configuring access control list AV pairs on the security server. For a list of valid AV pairs, refer to the chapter “Authentication Commands” in the *Cisco IOS Security Command Reference*.
- If you want remote users to use the interface’s existing authorization (that which existed prior to the second stage authentication/authorization), but you want them to have different access control lists (ACLs), you should specify *only* ACL AV pairs in the user-specific authorization definition. This might be desirable if you set up a default authorization profile to apply to the remote host, but want to apply specific ACLs to specific users.
- When these user-specific authorization statements are later applied to the interface, they can either be *added* to the existing interface configuration or they can *replace* the existing interface configuration—depending on which form of the **access-profile** command is used to authorize the user. You should understand how the **access-profile** command works before configuring the authorization statements.
- If you will be using ISDN or Multilink PPP, you must also configure virtual templates at the local host.

To troubleshoot double authentication, use the **debug aaa per-user** debug command. For more information about this command, refer to the *Cisco IOS Debug Command Reference*.

Accessing the User Profile After Double Authentication

In double authentication, when a remote user establishes a PPP link to the local host using the local host name, the remote host is CHAP (or PAP) authenticated. After CHAP (or PAP) authentication, PPP negotiates with AAA to assign network access privileges associated with the remote host to the user. (We suggest that privileges at this stage be restricted to allow the user to connect to the local host only by establishing a Telnet connection.)

When the user needs to initiate the second phase of double authentication, establishing a Telnet connection to the local host, the user enters a personal username and password (different from the CHAP or PAP username and password). This action causes AAA reauthentication to occur according to the

personal username/password. The initial rights associated with the local host, though, are still in place. By using the **access-profile** command, the rights associated with the local host are replaced by or merged with those defined for the user in the user's profile.

To access the user profile after double authentication, use the following command in EXEC configuration mode:

Command	Purpose
Router> access-profile [merge replace] [ignore-sanity-checks]	Accesses the rights associated for the user after double authentication.

If you configured the **access-profile** command to be executed as an autocommand, it will be executed automatically after the remote user logs in.

Enabling Automated Double Authentication

You can make the double authentication process easier for users by implementing automated double authentication. Automated double authentication provides all of the security benefits of double authentication, but offers a simpler, more user-friendly interface for remote users. With double authentication, a second level of user authentication is achieved when the user Telnets to the network access server or router and enters a username and password. With automated double authentication, the user does not have to Telnet to the network access server; instead the user responds to a dialog box that requests a username and password or personal identification number (PIN). To use the automated double authentication feature, the remote user hosts must be running a companion client application. As of Cisco IOS Release 12.0, the only client application software available is the Glacier Bay application server software for PCs.



Note

Automated double authentication, like the existing double authentication feature, is for Multilink PPP ISDN connections only. Automated double authentication cannot be used with other protocols such as X.25 or SLIP.

Automated double authentication is an enhancement to the existing double authentication feature. To configure automated double authentication, you must first configure double authentication by completing the following steps:

1. Enable AAA by using the **aaa-new model** global configuration command. For more information about enabling AAA, refer to the chapter "AAA Overview."
2. Use the **aaa authentication** command to configure your network access server to use login and PPP authentication method lists, then apply those method lists to the appropriate lines or interfaces.
3. Use the **aaa authorization** command to configure AAA network authorization at login. For more information about configuring network authorization, refer to the chapter "Configuring Authorization."
4. Configure security protocol parameters (for example, RADIUS or TACACS+). For more information about RADIUS, refer to the chapter "Configuring RADIUS". For more information about TACACS+, refer to the chapter "Configuring TACACS+."

5. Use access control list AV pairs on the security server that the user can connect to the local host only by establishing a Telnet connection.
6. Configure the **access-profile** command as an autocommand. If you configure the autocommand, remote users will not have to manually enter the **access-profile** command to access authorized rights associated with their personal user profile. To learn about configuring autocommands, refer to the **autocommand** command in the *Cisco IOS Dial Technologies Command Reference*, Release 12.2.

**Note**

If the **access-profile** command is configured as an autocommand, users will still have to Telnet to the local host and log in to complete double authentication.

Follow these rules when creating the user-specific authorization statements (These rules relate to the default behavior of the **access-profile** command):

- Use valid AV pairs when configuring access control list AV pairs on the security server. For a list of valid AV pairs, refer to the chapter “Authentication Commands” in the *Cisco IOS Security Command Reference*.
- If you want remote users to use the interface’s existing authorization (that which existed prior to the second stage authentication/authorization), but you want them to have different access control lists (ACLs), you should specify *only* ACL AV pairs in the user-specific authorization definition. This might be desirable if you set up a default authorization profile to apply to the remote host, but want to apply specific ACLs to specific users.
- When these user-specific authorization statements are later applied to the interface, they can either be *added* to the existing interface configuration, or *replace* the existing interface configuration—depending on which form of the **access-profile** command is used to authorize the user. You should understand how the **access-profile** command works before configuring the authorization statements.
- If you will be using ISDN or Multilink PPP, you must also configure virtual templates at the local host.

To troubleshoot double authentication, use the **debug aaa per-user** debug command. For more information about this command, refer to the *Cisco IOS Debug Command Reference*.

After you have configured double authentication, you are ready to configure the automation enhancement.

To configure automated double authentication, use the following commands, starting in global configuration mode.

:

	Command	Purpose
Step 1	Router(config)# ip trigger-authentication [timeout seconds] [port number]	Enables automation of double authentication.
Step 2	Router(config)# interface bri <i>number</i> or Router(config)# interface serial <i>number:23</i>	Selects an ISDN BRI or ISDN PRI interface and enter the interface configuration mode.
Step 3	Router(config-if)# ip trigger-authentication	Applies automated double authentication to the interface.

To troubleshoot automated double authentication, use the following commands in privileged EXEC mode:

	Command	Purpose
Step 1	Router# show ip trigger-authentication	Displays the list of remote hosts for which automated double authentication has been attempted (successfully or unsuccessfully).
Step 2	Router# clear ip trigger-authentication	Clears the list of remote hosts for which automated double authentication has been attempted. (This clears the table displayed by the show ip trigger-authentication command.)
Step 3	Router# debug ip trigger-authentication	Displays debug output related to automated double authentication.

Non-AAA Authentication Methods

This section discusses the following non-AAA authentication tasks:

- [Configuring Line Password Protection](#)
- [Establishing Username Authentication](#)
- [Enabling CHAP or PAP Authentication](#)
- [Using MS-CHAP](#)

Configuring Line Password Protection

You can provide access control on a terminal line by entering the password and establishing password checking. To do so, use the following commands in line configuration mode:

	Command	Purpose
Step 1	Router(config-line)# password <i>password</i>	Assigns a password to a terminal or other device on a line.
Step 2	Router(config-line)# login	Enables password checking at login.

The password checker is case sensitive and can include spaces; for example, the password “Secret” is different from the password “secret,” and “two words” is an acceptable password.

You can disable line password verification by disabling password checking. To do so, use the following command in line configuration mode:

Command	Purpose
Router(config-line)# no login	Disables password checking or allow access to a line without password verification.

If you configure line password protection and then configure TACACS or extended TACACS, the TACACS username and password take precedence over line passwords. If you have not yet implemented a security policy, we recommend that you use AAA.

**Note**

The **login** command only changes username and privilege level but it does not execute a shell; therefore autocommands will not be executed. To execute autocommands under this circumstance, you need to establish a Telnet session back into the router (loop-back). Make sure that the router has been configured for secure Telnet sessions if you choose to implement autocommands this way.

Establishing Username Authentication

You can create a username-based authentication system, which is useful in the following situations:

- To provide a TACACS-like username and encrypted password-authentication system for networks that cannot support TACACS
- To provide special-case logins: for example, access list verification, no password verification, autocommand execution at login, and “no escape” situations

To establish username authentication, use the following commands in global configuration mode as needed for your system configuration:

	Command	Purpose
Step 1	Router(config)# username <i>name</i> [no password password <i>password</i> password <i>encryption-type</i> <i>encrypted password</i>]	Establishes username authentication with encrypted passwords.
	or Router(config)# username <i>name</i> [access-class <i>number</i>]	(Optional) Establishes username authentication by access list.
Step 2	Router(config)# username <i>name</i> [privilege <i>level</i>]	(Optional) Sets the privilege level for the user.
Step 3	Router(config)# username <i>name</i> [autocommand <i>command</i>]	(Optional) Specifies a command to be executed automatically.
Step 4	Router(config)# username <i>name</i> [noescape] [nohangup]	(Optional) Sets a “no escape” login environment.

The keyword **noescape** prevents users from using escape characters on the hosts to which they are connected. The **nohangup** feature does not disconnect after using the autocommand.

**Caution**

Passwords will be displayed in clear text in your configuration unless you enable the **service password-encryption** command. For more information about the **service password-encryption** command, refer to the chapter “Passwords and Privileges Commands” in the *Cisco IOS Security Command Reference*.

Enabling CHAP or PAP Authentication

One of the most common transport protocols used in Internet service providers' (ISPs') dial solutions is the Point-to-Point Protocol (PPP). Traditionally, remote users dial in to an access server to initiate a PPP session. After PPP has been negotiated, remote users are connected to the ISP network and to the Internet.

Because ISPs want only customers to connect to their access servers, remote users are required to authenticate to the access server before they can start up a PPP session. Normally, a remote user authenticates by typing in a username and password when prompted by the access server. Although this is a workable solution, it is difficult to administer and awkward for the remote user.

A better solution is to use the authentication protocols built into PPP. In this case, the remote user dials in to the access server and starts up a minimal subset of PPP with the access server. This does not give the remote user access to the ISP's network—it merely allows the access server to talk to the remote device.

PPP currently supports two authentication protocols: Password Authentication Protocol (PAP) and Challenge Handshake Authentication Protocol (CHAP). Both are specified in RFC 1334 and are supported on synchronous and asynchronous interfaces. Authentication via PAP or CHAP is equivalent to typing in a username and password when prompted by the server. CHAP is considered to be more secure because the remote user's password is never sent across the connection.

PPP (with or without PAP or CHAP authentication) is also supported in dialout solutions. An access server utilizes a dialout feature when it initiates a call to a remote device and attempts to start up a transport protocol such as PPP.

See the chapter “Configuring Interfaces” in the *Cisco IOS Configuration Fundamentals Configuration Guide* for more information about CHAP and PAP.

**Note**

To use CHAP or PAP, you must be running PPP encapsulation.

When CHAP is enabled on an interface and a remote device attempts to connect to it, the access server sends a CHAP packet to the remote device. The CHAP packet requests or “challenges” the remote device to respond. The challenge packet consists of an ID, a random number, and the host name of the local router.

When the remote device receives the challenge packet, it concatenates the ID, the remote device's password, and the random number, and then encrypts all of it using the remote device's password. The remote device sends the results back to the access server, along with the name associated with the password used in the encryption process.

When the access server receives the response, it uses the name it received to retrieve a password stored in its user database. The retrieved password should be the same password the remote device used in its encryption process. The access server then encrypts the concatenated information with the newly retrieved password—if the result matches the result sent in the response packet, authentication succeeds.

The benefit of using CHAP authentication is that the remote device's password is never transmitted in clear text. This prevents other devices from stealing it and gaining illegal access to the ISP's network.

CHAP transactions occur only at the time a link is established. The access server does not request a password during the rest of the call. (The local device can, however, respond to such requests from other devices during a call.)

When PAP is enabled, the remote router attempting to connect to the access server is required to send an authentication request. If the username and password specified in the authentication request are accepted, the Cisco IOS software sends an authentication acknowledgment.

After you have enabled CHAP or PAP, the access server will require authentication from remote devices dialing in to the access server. If the remote device does not support the enabled protocol, the call will be dropped.

To use CHAP or PAP, you must perform the following tasks:

1. Enable PPP encapsulation.
2. Enable CHAP or PAP on the interface.
3. For CHAP, configure host name authentication and the secret or password for each remote system with which authentication is required.

This section includes the following sections:

- [Enabling PPP Encapsulation](#)
- [Enabling PAP or CHAP](#)
- [Inbound and Outbound Authentication](#)
- [Enabling Outbound PAP Authentication](#)
- [Refusing PAP Authentication Requests](#)
- [Creating a Common CHAP Password](#)
- [Refusing CHAP Authentication Requests](#)
- [Delaying CHAP Authentication Until Peer Authenticates](#)

Enabling PPP Encapsulation

To enable PPP encapsulation, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# encapsulation ppp	Enables PPP on an interface.

Enabling PAP or CHAP

To enable CHAP or PAP authentication on an interface configured for PPP encapsulation, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# ppp authentication { <i>protocol1</i> [<i>protocol2...</i>] [<i>if-needed</i>] { <i>default</i> <i>list-name</i> } [<i>callin</i>] [<i>one-time</i> }	Defines the authentication protocols supported and the order in which they are used. In this command, <i>protocol1</i> , <i>protocol2</i> represent the following protocols: CHAP, MS-CHAP, and PAP. PPP authentication is attempted first using the first authentication method, which is <i>protocol1</i> . If <i>protocol1</i> is unable to establish authentication, the next configured protocol is used to negotiate authentication.

If you configure **ppp authentication chap** on an interface, all incoming calls on that interface that initiate a PPP connection will have to be authenticated using CHAP; likewise, if you configure **ppp authentication pap**, all incoming calls that start a PPP connection will have to be authenticated via PAP. If you configure **ppp authentication chap pap**, the access server will attempt to authenticate all

incoming calls that start a PPP session with CHAP. If the remote device does not support CHAP, the access server will try to authenticate the call using PAP. If the remote device does not support either CHAP or PAP, authentication will fail and the call will be dropped. If you configure **ppp authentication pap chap**, the access server will attempt to authenticate all incoming calls that start a PPP session with PAP. If the remote device does not support PAP, the access server will try to authenticate the call using CHAP. If the remote device does not support either protocol, authentication will fail and the call will be dropped. If you configure the **ppp authentication** command with the **callin** keyword, the access server will only authenticate the remote device if the remote device initiated the call.

Authentication method lists and the **one-time** keyword are only available if you have enabled AAA—they will not be available if you are using TACACS or extended TACACS. If you specify the name of an authentication method list with the **ppp authentication** command, PPP will attempt to authenticate the connection using the methods defined in the specified method list. If AAA is enabled and no method list is defined by name, PPP will attempt to authenticate the connection using the methods defined as the default. The **ppp authentication** command with the **one-time** keyword enables support for one-time passwords during authentication.

The **if-needed** keyword is only available if you are using TACACS or extended TACACS. The **ppp authentication** command with the **if-needed** keyword means that PPP will only authenticate the remote device via PAP or CHAP if they have not yet authenticated during the life of the current call. If the remote device authenticated via a standard login procedure and initiated PPP from the EXEC prompt, PPP will not authenticate via CHAP if **ppp authentication chap if-needed** is configured on the interface.

**Caution**

If you use a *list-name* that has not been configured with the **aaa authentication ppp** command, you disable PPP on the line.

For information about adding a **username** entry for each remote system from which the local router or access server requires authentication, see the section “[Establishing Username Authentication](#).”

Inbound and Outbound Authentication

PPP supports two-way authentication. Normally, when a remote device dials in to an access server, the access server requests that the remote device prove that it is allowed access. This is known as inbound authentication. At the same time, the remote device can also request that the access server prove that it is who it says it is. This is known as outbound authentication. An access server also does outbound authentication when it initiates a call to a remote device.

Enabling Outbound PAP Authentication

To enable outbound PAP authentication, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# ppp pap sent-username <i>username</i> password <i>password</i>	Enables outbound PAP authentication.

The access server uses the username and password specified by the **ppp pap sent-username** command to authenticate itself whenever it initiates a call to a remote device or when it has to respond to a remote device's request for outbound authentication.

Refusing PAP Authentication Requests

To refuse PAP authentication from peers requesting it, meaning that PAP authentication is disabled for all calls, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# ppp pap refuse	Refuses PAP authentication from peers requesting PAP authentication.

If the **refuse** keyword is not used, the router will not refuse any PAP authentication challenges received from the peer.

Creating a Common CHAP Password

For remote CHAP authentication only, you can configure your router to create a common CHAP secret password to use in response to challenges from an unknown peer; for example, if your router calls a rotary of routers (either from another vendor, or running an older version of the Cisco IOS software) to which a new (that is, unknown) router has been added. The **ppp chap password** command allows you to replace several username and password configuration commands with a single copy of this command on any dialer interface or asynchronous group interface.

To enable a router calling a collection of routers to configure a common CHAP secret password, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# ppp chap password secret	Enables a router calling a collection of routers to configure a common CHAP secret password.

Refusing CHAP Authentication Requests

To refuse CHAP authentication from peers requesting it, meaning that CHAP authentication is disabled for all calls, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# ppp chap refuse [callin]	Refuses CHAP authentication from peers requesting CHAP authentication.

If the **callin** keyword is used, the router will refuse to answer CHAP authentication challenges received from the peer, but will still require the peer to answer any CHAP challenges the router sends.

If outbound PAP has been enabled (using the **ppp pap sent-username** command), PAP will be suggested as the authentication method in the refusal packet.

Delaying CHAP Authentication Until Peer Authenticates

To specify that the router will not authenticate to a peer requesting CHAP authentication until after the peer has authenticated itself to the router, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# ppp chap wait secret	Configures the router to delay CHAP authentication until after the peer has authenticated itself to the router.

This command (which is the default) specifies that the router will not authenticate to a peer requesting CHAP authentication until the peer has authenticated itself to the router. The **no ppp chap wait** command specifies that the router will respond immediately to an authentication challenge.

Using MS-CHAP

Microsoft Challenge Handshake Authentication Protocol (MS-CHAP) is the Microsoft version of CHAP and is an extension of RFC 1994. Like the standard version of CHAP, MS-CHAP is used for PPP authentication; in this case, authentication occurs between a PC using Microsoft Windows NT or Microsoft Windows 95 and a Cisco router or access server acting as a network access server.

MS-CHAP differs from the standard CHAP as follows:

- MS-CHAP is enabled by negotiating CHAP Algorithm 0x80 in LCP option 3, Authentication Protocol.
- The MS-CHAP Response packet is in a format designed to be compatible with Microsoft Windows NT 3.5 and 3.51, Microsoft Windows 95, and Microsoft LAN Manager 2.x. This format does not require the authenticator to store a clear or reversibly encrypted password.
- MS-CHAP provides an authenticator-controlled authentication retry mechanism.
- MS-CHAP provides an authenticator-controlled change password mechanism.
- MS-CHAP defines a set of “reason-for failure” codes returned in the Failure packet message field.

Depending on the security protocols you have implemented, PPP authentication using MS-CHAP can be used with or without AAA security services. If you have enabled AAA, PPP authentication using MS-CHAP can be used in conjunction with both TACACS+ and RADIUS. [Table 9](#) lists the vendor-specific RADIUS attributes (IETF Attribute 26) that enable RADIUS to support MS-CHAP.

Table 9 Vendor-Specific RADIUS Attributes for MS-CHAP

Vendor-ID Number	Vendor-Type Number	Vendor-Proprietary Attribute	Description
311	11	MSCHAP-Challenge	Contains the challenge sent by a network access server to an MS-CHAP user. It can be used in both Access-Request and Access-Challenge packets.
211	11	MSCHAP-Response	Contains the response value provided by a PPP MS-CHAP user in response to the challenge. It is only used in Access-Request packets. This attribute is identical to the PPP CHAP Identifier.

To define PPP authentication using MS-CHAP, use the following commands in interface configuration mode:

	Command	Purpose
Step 1	Router(config-if)# encapsulation ppp	Enables PPP encapsulation.
Step 2	Router(config-if)# ppp authentication ms-chap [if-needed] [list-name default] [callin] [one-time]	Defines PPP authentication using MS-CHAP.

If you configure **ppp authentication ms-chap** on an interface, all incoming calls on that interface that initiate a PPP connection will have to be authenticated using MS-CHAP. If you configure the **ppp authentication** command with the **callin** keyword, the access server will only authenticate the remote device if the remote device initiated the call.

Authentication method lists and the **one-time** keyword are only available if you have enabled AAA—they will not be available if you are using TACACS or extended TACACS. If you specify the name of an authentication method list with the **ppp authentication** command, PPP will attempt to authenticate the connection using the methods defined in the specified method list. If AAA is enabled and no method list is defined by name, PPP will attempt to authenticate the connection using the methods defined as the default. The **ppp authentication** command with the **one-time** keyword enables support for one-time passwords during authentication.

The **if-needed** keyword is only available if you are using TACACS or extended TACACS. The **ppp authentication** command with the **if-needed** keyword means that PPP will only authenticate the remote device via MS-CHAP if that device has not yet authenticated during the life of the current call. If the remote device authenticated through a standard login procedure and initiated PPP from the EXEC prompt, PPP will not authenticate through MS-CHAP if **ppp authentication chap if-needed** is configured.



Note

If PPP authentication using MS-CHAP is used with username authentication, you must include the MS-CHAP secret in the local username/password database. For more information about username authentication, refer to the “Establish Username Authentication” section.

Authentication Examples

The following sections provide authentication configuration examples:

- [RADIUS Authentication Examples](#)
- [TACACS+ Authentication Examples](#)
- [Kerberos Authentication Examples](#)
- [AAA Scalability Example](#)
- [Login and Failed Banner Examples](#)
- [AAA Packet of Disconnect Server Key Example](#)
- [Double Authentication Examples](#)
- [Automated Double Authentication Example](#)
- [MS-CHAP Example](#)

RADIUS Authentication Examples

This section provides two sample configurations using RADIUS.

The following example shows how to configure the router to authenticate and authorize using RADIUS:

```
aaa authentication login radius-login group radius local
aaa authentication ppp radius-ppp if-needed group radius
aaa authorization exec default group radius if-authenticated
aaa authorization network default group radius
line 3
login authentication radius-login
interface serial 0
ppp authentication radius-ppp
```

The lines in this sample RADIUS authentication and authorization configuration are defined as follows:

- The **aaa authentication login radius-login group radius local** command configures the router to use RADIUS for authentication at the login prompt. If RADIUS returns an error, the user is authenticated using the local database.
- The **aaa authentication ppp radius-ppp if-needed group radius** command configures the Cisco IOS software to use PPP authentication using CHAP or PAP if the user has not already logged in. If the EXEC facility has authenticated the user, PPP authentication is not performed.
- The **aaa authorization exec default group radius if-authenticated** command queries the RADIUS database for information that is used during EXEC authorization, such as autocommands and privilege levels, but only provides authorization if the user has successfully authenticated.
- The **aaa authorization network default group radius** command queries RADIUS for network authorization, address assignment, and other access lists.
- The **login authentication radius-login** command enables the radius-login method list for line 3.
- The **ppp authentication radius-ppp** command enables the radius-ppp method list for serial interface 0.

The following example shows how to configure the router to prompt for and verify a username and password, authorize the user's EXEC level, and specify it as the method of authorization for privilege level 2. In this example, if a local username is entered at the username prompt, that username is used for authentication.

If the user is authenticated using the local database, EXEC authorization using RADIUS will fail because no data is saved from the RADIUS authentication. The method list also uses the local database to find an autocommand. If there is no autocommand, the user becomes the EXEC user. If the user then attempts to issue commands that are set at privilege level 2, TACACS+ is used to attempt to authorize the command.

```
aaa authentication login default group radius local
aaa authorization exec default group radius local
aaa authorization command 2 default group tacacs+ if-authenticated
radius-server host 172.16.71.146 auth-port 1645 acct-port 1646
radius-server attribute 44 include-in-access-req
radius-server attribute 8 include-in-access-req
```

The lines in this sample RADIUS authentication and authorization configuration are defined as follows:

- The **aaa authentication login default group radius local** command specifies that the username and password are verified by RADIUS or, if RADIUS is not responding, by the router's local user database.
- The **aaa authorization exec default group radius local** command specifies that RADIUS authentication information be used to set the user's EXEC level if the user authenticates with RADIUS. If no RADIUS information is used, this command specifies that the local user database be used for EXEC authorization.
- The **aaa authorization command 2 default group tacacs+ if-authenticated** command specifies TACACS+ authorization for commands set at privilege level 2, if the user has already successfully authenticated.
- The **radius-server host 172.16.71.146 auth-port 1645 acct-port 1646** command specifies the IP address of the RADIUS server host, the UDP destination port for authentication requests, and the UDP destination port for accounting requests.
- The **radius-server attribute 44 include-in-access-req** command sends RADIUS attribute 44 (Acct-Session-ID) in access-request packets.
- The **radius-server attribute 8 include-in-access-req** command sends RADIUS attribute 8 (Framed-IP-Address) in access-request packets.

TACACS+ Authentication Examples

The following example shows how to configure TACACS+ as the security protocol to be used for PPP authentication:

```
aaa new-model
aaa authentication ppp test group tacacs+ local
interface serial 0
ppp authentication chap pap test
tacacs-server host 10.1.2.3
tacacs-server key goaway
```

The lines in this sample TACACS+ authentication configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines a method list, "test," to be used on serial interfaces running PPP. The keywords **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.
- The **interface** command selects the line.
- The **ppp authentication** command applies the test method list to this line.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.1.2.3.
- The **tacacs-server key** command defines the shared encryption key to be "goaway."

The following example shows how to configure AAA authentication for PPP:

```
aaa authentication ppp default if-needed group tacacs+ local
```

In this example, the keyword **default** means that PPP authentication is applied by default to all interfaces. The **if-needed** keyword means that if the user has already authenticated by going through the ASCII login procedure, then PPP is not necessary and can be skipped. If authentication is needed, the

keywords **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.

The following example shows how to create the same authentication algorithm for PAP, but it calls the method list “MIS-access” instead of “default”:

```
aaa authentication ppp MIS-access if-needed group tacacs+ local
interface serial 0
ppp authentication pap MIS-access
```

In this example, because the list does not apply to any interfaces (unlike the default list, which applies automatically to all interfaces), the administrator must select interfaces to which this authentication scheme should apply by using the **interface** command. The administrator must then apply this method list to those interfaces by using the **ppp authentication** command.

Kerberos Authentication Examples

To specify Kerberos as the login authentication method, use the following command:

```
aaa authentication login default krb5
```

To specify Kerberos authentication for PPP, use the following command:

```
aaa authentication ppp default krb5
```

AAA Scalability Example

The following example shows a general security configuration using AAA with RADIUS as the security protocol. In this example, the network access server is configured to allocate 16 background processes to handle AAA requests for PPP.

```
aaa new-model
radius-server host alcatraz
radius-server key myRaDiUSpassWoRd
radius-server configure-nas
username root password ALongPassword
aaa authentication ppp dialins group radius local
aaa authentication login admins local
aaa authorization network default group radius local
aaa accounting network default start-stop group radius
aaa processes 16
line 1 16
  autoselect ppp
  autoselect during-login
  login authentication admins
  modem dialin
interface group-async 1
  group-range 1 16
  encapsulation ppp
  ppp authentication pap dialins
```

The lines in this sample RADIUS AAA configuration are defined as follows:

- The **aaa new-model** command enables AAA network security services.
- The **radius-server host** command defines the name of the RADIUS server host.
- The **radius-server key** command defines the shared secret text string between the network access server and the RADIUS server host.

- The **radius-server configure-nas** command defines that the Cisco router or access server will query the RADIUS server for static routes and IP pool definitions when the device first starts up.
- The **username** command defines the username and password to be used for the PPP Password Authentication Protocol (PAP) caller identification.
- The **aaa authentication ppp dialins group radius local** command defines the authentication method list “dialins,” which specifies that RADIUS authentication, then (if the RADIUS server does not respond) local authentication will be used on serial lines using PPP.
- The **aaa authentication login admins local** command defines another method list, “admins,” for login authentication.
- The **aaa authorization network default group radius local** command is used to assign an address and other network parameters to the RADIUS user.
- The **aaa accounting network default start-stop group radius** command tracks PPP usage.
- The **aaa processes** command allocates 16 background processes to handle AAA requests for PPP.
- The **line** command switches the configuration mode from global configuration to line configuration and identifies the specific lines being configured.
- The **autoselect ppp** command configures the Cisco IOS software to allow a PPP session to start up automatically on these selected lines.
- The **autoselect during-login** command is used to display the username and password prompt without pressing the Return key. After the user logs in, the autoselect function (in this case, PPP) begins.
- The **login authentication admins** command applies the “admins” method list for login authentication.
- The **modem dialin** command configures modems attached to the selected lines to only accept incoming calls.
- The **interface group-async** command selects and defines an asynchronous interface group.
- The **group-range** command defines the member asynchronous interfaces in the interface group.
- The **encapsulation ppp** command sets PPP as the encapsulation method used on the specified interfaces.
- The **ppp authentication pap dialins** command applies the “dialins” method list to the specified interfaces.

Login and Failed Banner Examples

The following example shows how to configure a login banner (in this case, the phrase “Unauthorized Access Prohibited”) that will be displayed when a user logs in to the system. The asterisk (*) is used as the delimiting character. (RADIUS is specified as the default login authentication method.)

```
aaa new-model
aaa authentication banner *Unauthorized Access Prohibited*
aaa authentication login default group radius
```

This configuration produces the following login banner:

```
Unauthorized Access Prohibited
Username:
```

The following example shows how to additionally configure a failed login banner (in this case, the phrase “Failed login. Try again.”) that will be displayed when a user tries to log in to the system and fails. The asterisk (*) is used as the delimiting character. (RADIUS is specified as the default login authentication method.)

```
aaa new-model
aaa authentication banner *Unauthorized Access Prohibited*
aaa authentication fail-message *Failed login. Try again.*
aaa authentication login default group radius
```

This configuration produces the following login and failed login banner:

```
Unauthorized Access Prohibited
Username:
Password:
Failed login. Try again.
```

AAA Packet of Disconnect Server Key Example

The following example shows how to configure POD (packet of disconnect), which terminates connections on the network access server (NAS) when particular session attributes are identified.

```
aaa new-model
aaa authentication ppp default radius
aaa accounting network default start-stop radius
aaa accounting delay-start
aaa pod server server-key xyz123
radius-server host 172.16.0.0 non-standard
radius-server key rad123
```

Double Authentication Examples

The examples in this section illustrate possible configurations to be used with double authentication. Your configurations could differ significantly, depending on your network and security requirements.

This section includes the following examples:

- [Configuration of the Local Host for AAA with Double Authentication Examples](#)
- [Configuration of the AAA Server for First-Stage \(PPP\) Authentication and Authorization Example](#)
- [Configuration of the AAA Server for Second-Stage \(Per-User\) Authentication and Authorization Examples](#)
- [Complete Configuration with TACACS+ Example](#)



Note

These configuration examples include specific IP addresses and other specific information. This information is for illustration purposes only; your configuration will use different IP addresses, different usernames and passwords, and different authorization statements.

Configuration of the Local Host for AAA with Double Authentication Examples

These two examples show how to configure a local host to use AAA for PPP and login authentication, and for network and EXEC authorization. One example is shown for RADIUS and one example for TACACS+.

In both examples, the first three lines configure AAA, with a specific server as the AAA server. The next two lines configure AAA for PPP and login authentication, and the last two lines configure network and EXEC authorization. The last line is necessary only if the **access-profile** command will be executed as an autocommand.

The following example shows router configuration with a RADIUS AAA server:

```
aaa new-model
radius-server host secureserver
radius-server key myradiuskey
aaa authentication ppp default group radius
aaa authentication login default group radius
aaa authorization network default group radius
aaa authorization exec default group radius
```

The following example shows router configuration with a TACACS+ server:

```
aaa new-model
tacacs-server host security
tacacs-server key mytacacskey
aaa authentication ppp default group tacacs+
aaa authentication login default group tacacs+
aaa authorization network default group tacacs+
aaa authorization exec default group tacacs+
```

Configuration of the AAA Server for First-Stage (PPP) Authentication and Authorization Example

This example shows a configuration on the AAA server. A partial sample AAA configuration is shown for RADIUS.

TACACS+ servers can be configured similarly. (See the section “[Complete Configuration with TACACS+ Example](#)” later in this chapter.)

This example defines authentication/authorization for a remote host named “hostx” that will be authenticated by CHAP in the first stage of double authentication. Note that the ACL AV pair limits the remote host to Telnet connections to the local host. The local host has the IP address 10.0.0.2.

The following example shows a partial AAA server configuration for RADIUS:

```
hostx Password = "welcome"
User-Service-Type = Framed-User,
Framed-Protocol = PPP,
cisco-avpair = "lcp:interface-config=ip unnumbered ethernet 0",
cisco-avpair = "ip:inacl#3=permit tcp any 172.21.114.0 0.0.0.255 eq telnet",
cisco-avpair = "ip:inacl#4=deny icmp any any",
cisco-avpair = "ip:route#5=55.0.0.0 255.0.0.0",
cisco-avpair = "ip:route#6=66.0.0.0 255.0.0.0",
cisco-avpair = "ipx:inacl#3=deny any"
```

Configuration of the AAA Server for Second-Stage (Per-User) Authentication and Authorization Examples

This section contains partial sample AAA configurations on a RADIUS server. These configurations define authentication and authorization for a user (Pat) with the username “patuser,” who will be user-authenticated in the second stage of double authentication.

TACACS+ servers can be configured similarly. (See the section “[Complete Configuration with TACACS+ Example](#)” later in this chapter.)

Three examples show sample RADIUS AAA configurations that could be used with each of the three forms of the **access-profile** command.

The first example shows a partial sample AAA configuration that works with the default form (no keywords) of the **access-profile** command. Note that only ACL AV pairs are defined. This example also sets up the **access-profile** command as an autocommand.

```
patuser Password = "welcome"
        User-Service-Type = Shell-User,
        cisco-avpair = "shell:autocmd=access-profile"
        User-Service-Type = Framed-User,
        Framed-Protocol = PPP,
        cisco-avpair = "ip:inacl#3=permit tcp any host 10.0.0.2 eq telnet",
        cisco-avpair = "ip:inacl#4=deny icmp any any"
```

The second example shows a partial sample AAA configuration that works with the **access-profile merge** form of the **access-profile** command. This example also sets up the **access-profile merge** command as an autocommand.

```
patuser Password = "welcome"
        User-Service-Type = Shell-User,
        cisco-avpair = "shell:autocmd=access-profile merge"
        User-Service-Type = Framed-User,
        Framed-Protocol = PPP,
        cisco-avpair = "ip:inacl#3=permit tcp any any"
        cisco-avpair = "ip:route=10.0.0.0 255.255.0.0",
        cisco-avpair = "ip:route=10.1.0.0 255.255.0.0",
        cisco-avpair = "ip:route=10.2.0.0 255.255.0.0"
```

The third example shows a partial sample AAA configuration that works with the **access-profile replace** form of the **access-profile** command. This example also sets up the **access-profile replace** command as an autocommand.

```
patuser Password = "welcome"
        User-Service-Type = Shell-User,
        cisco-avpair = "shell:autocmd=access-profile replace"
        User-Service-Type = Framed-User,
        Framed-Protocol = PPP,
        cisco-avpair = "ip:inacl#3=permit tcp any any",
        cisco-avpair = "ip:inacl#4=permit icmp any any",
        cisco-avpair = "ip:route=10.10.0.0 255.255.0.0",
        cisco-avpair = "ip:route=10.11.0.0 255.255.0.0",
        cisco-avpair = "ip:route=10.12.0.0 255.255.0.0"
```

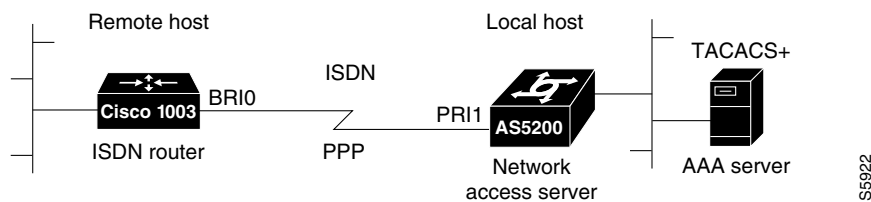
Complete Configuration with TACACS+ Example

This example shows TACACS+ authorization profile configurations both for the remote host (used in the first stage of double authentication) and for specific users (used in the second stage of double authentication). This TACACS+ example contains approximately the same configuration information as shown in the previous RADIUS examples.

This sample configuration shows authentication/authorization profiles on the TACACS+ server for the remote host “hostx” and for three users, with the usernames “pat_default,” “pat_merge,” and “pat_replace.” The configurations for these three usernames illustrate different configurations that correspond to the three different forms of the **access-profile** command. The three user configurations also illustrate setting up the autocommand for each form of the **access-profile** command.

Figure 5 shows the topology. The example that follows the figure shows a TACACS+ configuration file.

Figure 5 Example Topology for Double Authentication



This sample configuration shows authentication/authorization profiles on the TACACS+ server for the remote host “hostx” and for three users, with the usernames “pat_default,” “pat_merge,” and “pat_replace.”

```
key = "mytacacskey"
```

```
default authorization = permit
```

```
#-----Remote Host (BRI)-----
#
# This allows the remote host to be authenticated by the local host
# during fist-stage authentication, and provides the remote host
# authorization profile.
#
#-----

user = hostx
{
    login = cleartext "welcome"
    chap = cleartext "welcome"

    service = ppp protocol = lcp {
        interface-config="ip unnumbered ethernet 0"
    }

    service = ppp protocol = ip {
        # It is important to have the hash sign and some string after
        # it. This indicates to the NAS that you have a per-user
        # config.

        inacl#3="permit tcp any 172.21.114.0 0.0.0.255 eq telnet"
        inacl#4="deny icmp any any"
```

```

        route#5="55.0.0.0 255.0.0.0"
        route#6="66.0.0.0 255.0.0.0"
    }

    service = ppp protocol = ipx {
        # see previous comment about the hash sign and string, in protocol = ip
        inacl#3="deny any"
    }

}

#----- "access-profile" default user "only acls" -----
#
# Without arguments, access-profile removes any access-lists it can find
# in the old configuration (both per-user and per-interface), and makes sure
# that the new profile contains ONLY access-list definitions.
#
#-----

user = pat_default
{
    login = cleartext "welcome"
    chap = cleartext "welcome"

    service = exec

    {
        # This is the autocommand that executes when pat_default logs in.
        autocmd = "access-profile"
    }

    service = ppp protocol = ip {
        # Put whatever access-lists, static routes, whatever
        # here.
        # If you leave this blank, the user will have NO IP
        # access-lists (not even the ones installed prior to
        # this)!

        inacl#3="permit tcp any host 10.0.0.2 eq telnet"
        inacl#4="deny icmp any any"
    }

    service = ppp protocol = ipx {
        # Put whatever access-lists, static routes, whatever
        # here.
        # If you leave this blank, the user will have NO IPX
        # access-lists (not even the ones installed prior to
        # this)!
    }

}

#----- "access-profile merge" user -----
#
# With the 'merge' option, first all old access-lists are removed (as before),
# but then (almost) all AV pairs are uploaded and installed. This will allow
# for uploading any custom static routes, sap-filters, and so on, that the user
# may need in his or her profile. This needs to be used with care, as it leaves
# open the possibility of conflicting configurations.

```

```

#
#-----

user = pat_merge
{
    login = cleartext "welcome"
    chap = cleartext "welcome"

    service = exec
    {
        # This is the autocommand that executes when pat_merge logs in.
        autocmd = "access-profile merge"
    }

    service = ppp protocol = ip
    {
        # Put whatever access-lists, static routes, whatever
        # here.
        # If you leave this blank, the user will have NO IP
        # access-lists (not even the ones installed prior to
        # this)!

        inacl#3="permit tcp any any"
        route#2="10.0.0.0 255.255.0.0"
        route#3="10.1.0.0 255.255.0.0"
        route#4="10.2.0.0 255.255.0.0"

    }

    service = ppp protocol = ipx
    {
        # Put whatever access-lists, static routes, whatever
        # here.
        # If you leave this blank, the user will have NO IPX
        # access-lists (not even the ones installed prior to
        # this)!

    }

}

#----- "access-profile replace" user -----
#
# With the 'replace' option, ALL old configuration is removed and ALL new
# configuration is installed.
#
# One caveat: access-profile checks the new configuration for address-pool and
# address AV pairs. As addresses cannot be renegotiated at this point, the
# command will fail (and complain) when it encounters such an AV pair.
# Such AV pairs are considered to be "invalid" for this context.
#-----

user = pat_replace
{
    login = cleartext "welcome"
    chap = cleartext "welcome"

    service = exec
    {

```



```

        # This is the autocommand that executes when pat_replace logs in.
        autocmd = "access-profile replace"
    }

    service = ppp protocol = ip
    {
        # Put whatever access-lists, static routes, whatever
        # here.
        # If you leave this blank, the user will have NO IP
        # access-lists (not even the ones installed prior to
        # this)!

        inacl#3="permit tcp any any"
        inacl#4="permit icmp any any"

        route#2="10.10.0.0 255.255.0.0"
        route#3="10.11.0.0 255.255.0.0"
        route#4="10.12.0.0 255.255.0.0"
    }

    service = ppp protocol = ipx
    {
        # put whatever access-lists, static routes, whatever
        # here.
        # If you leave this blank, the user will have NO IPX
        # access-lists (not even the ones installed prior to
        # this)!
    }
}

```

Automated Double Authentication Example

This example shows a complete configuration file for a Cisco 2509 router with automated double authentication configured. The configuration commands that apply to automated double authentication are preceded by descriptions with a double asterisk (**).

Current configuration:

```

!
version 11.3
no service password-encryption
!
hostname myrouter
!
!
! **The following AAA commands are used to configure double authentication:
!
! **The following command enables AAA:
aaa new-model
! **The following command enables user authentication via the TACACS+ AAA server:
aaa authentication login default group tacacs+
aaa authentication login console none
! **The following command enables device authentication via the TACACS+ AAA server:
aaa authentication ppp default group tacacs+
! **The following command causes the remote user's authorization profile to be
! downloaded from the AAA server to the Cisco 2509 router when required:
aaa authorization exec default group tacacs+
! **The following command causes the remote device's authorization profile to be
! downloaded from the AAA server to the Cisco 2509 router when required:
aaa authorization network default group tacacs+

```

```

enable password mypassword
!
ip host blue 172.21.127.226
ip host green 172.21.127.218
ip host red 172.21.127.114
ip domain-name example.com
ip name-server 171.69.2.75
! **The following command globally enables automated double authentication:
ip trigger-authentication timeout 60 port 7500
isdn switch-type basic-5ess
!
!
interface Ethernet0
 ip address 172.21.127.186 255.255.255.248
 no ip route-cache
 no ip mroute-cache
 no keepalive
 ntp disable
 no cdp enable
!
interface Virtual-Template1
 ip unnumbered Ethernet0
 no ip route-cache
 no ip mroute-cache
!
interface Serial0
 ip address 172.21.127.105 255.255.255.248
 encapsulation ppp
 no ip mroute-cache
 no keepalive
 shutdown
 clockrate 2000000
 no cdp enable
!
interface Serial1
 no ip address
 no ip route-cache
 no ip mroute-cache
 shutdown
 no cdp enable
!
! **Automated double authentication occurs via the ISDN BRI interface BRI0:
interface BRI0
 ip unnumbered Ethernet0
! **The following command turns on automated double authentication at this interface:
ip trigger-authentication
! **PPP encapsulation is required:
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 dialer idle-timeout 500
 dialer map ip 172.21.127.113 name myrouter 60074
 dialer-group 1
 no cdp enable

```

```
! **The following command specifies that device authentication occurs via PPP CHAP:
ppp authentication chap
!
router eigrp 109
 network 172.21.0.0
 no auto-summary
!
ip default-gateway 172.21.127.185
no ip classless
ip route 172.21.127.114 255.255.255.255 172.21.127.113
! **Virtual profiles are required for double authentication to work:
virtual-profile virtual-template 1
dialer-list 1 protocol ip permit
no cdp run
! **The following command defines where the TACACS+ AAA server is:
tacacs-server host 171.69.57.35 port 1049
tacacs-server timeout 90
! **The following command defines the key to use with TACACS+ traffic (required):
tacacs-server key mytacacskey
snmp-server community public RO
!
line con 0
 exec-timeout 0 0
 login authentication console
line aux 0
 transport input all
line vty 0 4
 exec-timeout 0 0
 password lab
!
end
```

MS-CHAP Example

The following example shows how to configure a Cisco AS5200 Universal Access Server (enabled for AAA and communication with a RADIUS security server) for PPP authentication using MS-CHAP:

```
aaa new-model
aaa authentication login admins local
aaa authentication ppp dialins group radius local
aaa authorization network default group radius local
aaa accounting network default start-stop group radius

username root password ALongPassword

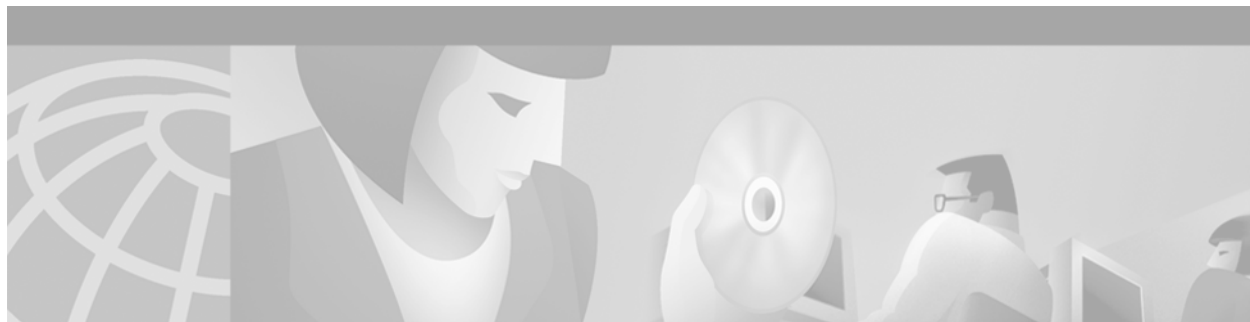
radius-server host alcatraz
radius-server key myRaDiUSpassWoRd

interface group-async 1
 group-range 1 16
 encapsulation ppp
 ppp authentication ms-chap dialins

line 1 16
 autoselect ppp
 autoselect during-login
 login authentication admins
 modem dialin
```

The lines in this sample RADIUS AAA configuration are defined as follows:

- The **aaa new-model** command enables AAA network security services.
- The **aaa authentication login admins local** command defines another method list, “admins”, for login authentication.
- The **aaa authentication ppp dialins group radius local** command defines the authentication method list “dialins,” which specifies that RADIUS authentication then (if the RADIUS server does not respond) local authentication will be used on serial lines using PPP.
- The **aaa authorization network default group radius local** command is used to assign an address and other network parameters to the RADIUS user.
- The **aaa accounting network default start-stop group radius** command tracks PPP usage.
- The **username** command defines the username and password to be used for the PPP Password Authentication Protocol (PAP) caller identification.
- The **radius-server host** command defines the name of the RADIUS server host.
- The **radius-server key** command defines the shared secret text string between the network access server and the RADIUS server host.
- The **interface group-async** command selects and defines an asynchronous interface group.
- The **group-range** command defines the member asynchronous interfaces in the interface group.
- The **encapsulation ppp** command sets PPP as the encapsulation method used on the specified interfaces.
- The **ppp authentication ms-chap dialins** command selects MS-CHAP as the method of PPP authentication and applies the “dialins” method list to the specified interfaces.
- The **line** command switches the configuration mode from global configuration to line configuration and identifies the specific lines being configured.
- The **autoselect ppp** command configures the Cisco IOS software to allow a PPP session to start up automatically on these selected lines.
- The **autoselect during-login** command is used to display the username and password prompt without pressing the Return key. After the user logs in, the autoselect function (in this case, PPP) begins.
- The **login authentication admins** command applies the “admins” method list for login authentication.
- The **modem dialin** command configures modems attached to the selected lines to only accept incoming calls.



Configuring Authorization

AAA authorization enables you to limit the services available to a user. When AAA authorization is enabled, the network access server uses information retrieved from the user's profile, which is located either in the local user database or on the security server, to configure the user's session. Once this is done, the user will be granted access to a requested service only if the information in the user profile allows it.

For a complete description of the authorization commands used in this chapter, refer to the chapter "Authorization Commands" in the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the chapter "Identifying Supported Platforms" section in the "Using Cisco IOS Software."

In This Chapter

This chapter contains the following sections:

- [Named Method Lists for Authorization](#)
- [AAA Authorization Methods](#)
- [Method Lists and Server Groups](#)
- [AAA Authorization Types](#)
- [AAA Authorization Prerequisites](#)
- [AAA Authorization Configuration Task List](#)
- [Authorization Attribute-Value Pairs](#)
- [Authorization Configuration Examples](#)

Named Method Lists for Authorization

Method lists for authorization define the ways that authorization will be performed and the sequence in which these methods will be performed. A method list is simply a named list describing the authorization methods to be queried (such as RADIUS or TACACS+), in sequence. Method lists enable you to designate one or more security protocols to be used for authorization, thus ensuring a backup system in case the initial method fails. Cisco IOS software uses the first method listed to authorize users for

specific network services; if that method fails to respond, the Cisco IOS software selects the next method listed in the method list. This process continues until there is successful communication with a listed authorization method, or all methods defined are exhausted.

**Note**

The Cisco IOS software attempts authorization with the next listed method only when there is no response from the previous method. If authorization fails at any point in this cycle—meaning that the security server or local username database responds by denying the user services—the authorization process stops and no other authorization methods are attempted.

Method lists are specific to the authorization type requested:

- **Auth-proxy**—Applies specific security policies on a per-user basis. For detailed information on the authentication proxy feature, refer to the chapter “Configuring Authentication Proxy” in the “Traffic Filtering and Firewalls” part of this book.
- **Commands**—Applies to the EXEC mode commands a user issues. Command authorization attempts authorization for all EXEC mode commands, including global configuration commands, associated with a specific privilege level.
- **EXEC**—Applies to the attributes associated with a user EXEC terminal session.
- **Network**—Applies to network connections. This can include a PPP, SLIP, or ARAP connection.
- **Reverse Access**—Applies to reverse Telnet sessions.

When you create a named method list, you are defining a particular list of authorization methods for the indicated authorization type.

Once defined, method lists must be applied to specific lines or interfaces before any of the defined methods will be performed. The only exception is the default method list (which is named “default”). If the **aaa authorization** command for a particular authorization type is issued without a named method list specified, the default method list is automatically applied to all interfaces or lines except those that have a named method list explicitly defined. (A defined method list overrides the default method list.) If no default method list is defined, local authorization takes place by default.

AAA Authorization Methods

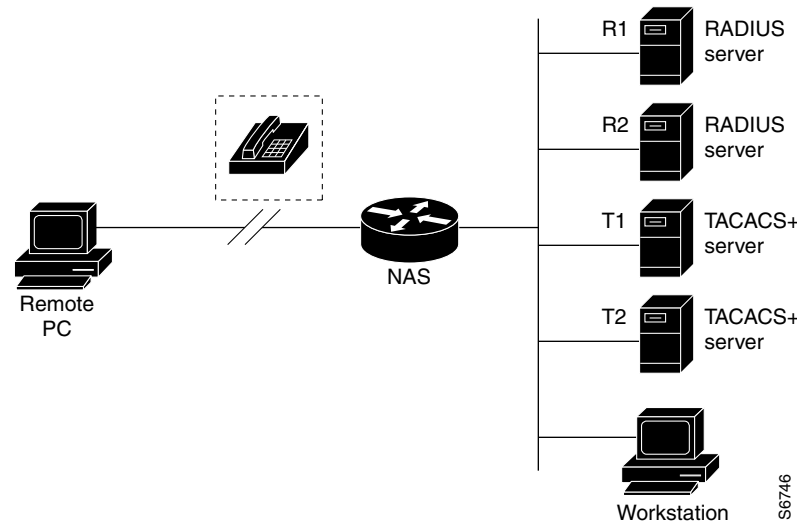
AAA supports five different methods of authorization:

- **TACACS+**—The network access server exchanges authorization information with the TACACS+ security daemon. TACACS+ authorization defines specific rights for users by associating attribute-value pairs, which are stored in a database on the TACACS+ security server, with the appropriate user.
- **If-Authenticated**—The user is allowed to access the requested function provided the user has been authenticated successfully.
- **None**—The network access server does not request authorization information; authorization is not performed over this line/interface.
- **Local**—The router or access server consults its local database, as defined by the **username** command, for example, to authorize specific rights for users. Only a limited set of functions can be controlled via the local database.
- **RADIUS**—The network access server requests authorization information from the RADIUS security server. RADIUS authorization defines specific rights for users by associating attributes, which are stored in a database on the RADIUS server, with the appropriate user.

Method Lists and Server Groups

A server group is a way to group existing RADIUS or TACACS+ server hosts for use in method lists. [Figure 6](#) shows a typical AAA network configuration that includes four security servers: R1 and R2 are RADIUS servers, and T1 and T2 are TACACS+ servers. R1 and R2 make up the group of RADIUS servers. T1 and T2 make up the group of TACACS+ servers.

Figure 6 Typical AAA Network Configuration



Using server groups, you can specify a subset of the configured server hosts and use them for a particular service. For example, server groups allow you to define R1 and R2 as separate server groups, and T1 and T2 as separate server groups. This means you can specify either R1 and T1 in the method list or R2 and T2 in the method list, which provides more flexibility in the way that you assign RADIUS and TACACS+ resources.

Server groups also can include multiple host entries for the same server, as long as each entry has a unique identifier. The combination of an IP address and a UDP port number creates a unique identifier, allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. In other words, this unique identifier enables RADIUS requests to be sent to different UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service—for example, authorization—the second host entry configured acts as fail-over backup to the first one. Using this example, if the first host entry fails to provide accounting services, the network access server will try the second host entry configured on the same device for accounting services. (The RADIUS host entries will be tried in the order they are configured.)

For more information about configuring server groups and about configuring server groups based on DNIS numbers, refer to the chapter “Configuring RADIUS” or the chapter “Configuring TACACS+”

AAA Authorization Types

Cisco IOS software supports five different types of authorization:

- **Auth-proxy**—Applies specific security policies on a per-user basis. For detailed information on the authentication proxy feature, refer to the “Configuring Authentication Proxy” chapter in the “Traffic Filtering and Firewalls” section of this book.
- **Commands**—Applies to the EXEC mode commands a user issues. Command authorization attempts authorization for all EXEC mode commands, including global configuration commands, associated with a specific privilege level.
- **EXEC**—Applies to the attributes associated with a user EXEC terminal session.
- **Network**—Applies to network connections. This can include a PPP, SLIP, or ARAP connection.
- **Reverse Access**—Applies to reverse Telnet sessions.
- **Configuration**—Applies to downloading configurations from the AAA server.
- **IP Mobile**—Applies to authorization for IP mobile services.

AAA Authorization Prerequisites

Before configuring authorization using named method lists, you must first perform the following tasks:

- **Enable AAA** on your network access server. For more information about enabling AAA on your Cisco router or access server, refer to the “AAA Overview” chapter.
- **Configure AAA authentication.** Authorization generally takes place after authentication and relies on authentication to work properly. For more information about AAA authentication, refer to the “Configuring Authentication” chapter.
- **Define the characteristics of your RADIUS or TACACS+ security server** if you are issuing RADIUS or TACACS+ authorization. For more information about configuring your Cisco network access server to communicate with your RADIUS security server, refer to the chapter “Configuring RADIUS”. For more information about configuring your Cisco network access server to communicate with your TACACS+ security server, refer to the chapter “Configuring TACACS+”.
- **Define the rights associated with specific users** by using the **username** command if you are issuing local authorization. For more information about the **username** command, refer to the *Cisco IOS Security Command Reference*.

AAA Authorization Configuration Task List

This section describes the following configuration tasks:

- [Configuring AAA Authorization Using Named Method Lists](#)
- [Disabling Authorization for Global Configuration Commands](#)
- [Configuring Authorization for Reverse Telnet](#)

For authorization configuration examples using the commands in this chapter, refer to the section “[Authorization Configuration Examples](#)” at the end of the this chapter.

Configuring AAA Authorization Using Named Method Lists

To configure AAA authorization using named method lists, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa authorization { auth-proxy network exec commands level reverse-access configuration ipmobile } { default <i>list-name</i> } [<i>method1</i> [<i>method2</i> ...]]	Creates an authorization method list for a particular authorization type and enable authorization.
Step 2	Router(config)# line [aux console tty vty] <i>line-number</i> [<i>ending-line-number</i>] or Router(config)# interface <i>interface-type</i> <i>interface-number</i>	Enters the line configuration mode for the lines to which you want to apply the authorization method list. Alternately, enters the interface configuration mode for the interfaces to which you want to apply the authorization method list.
Step 3	Router(config-line)# authorization { arap commands level exec reverse-access } { default <i>list-name</i> } or Router(config-line)# ppp authorization { default <i>list-name</i> }	Applies the authorization list to a line or set of lines. Alternately, applies the authorization list to an interface or set of interfaces.

This section includes the following sections:

- [Authorization Types](#)
- [Authorization Methods](#)

Authorization Types

Named authorization method lists are specific to the indicated type of authorization.

To create a method list to enable authorization that applies specific security policies on a per-user basis, use the **auth-proxy** keyword. For detailed information on the authentication proxy feature, refer to the chapter “Configuring Authentication Proxy” in the “Traffic Filtering and Firewalls” part of this book.

To create a method list to enable authorization for all network-related service requests (including SLIP, PPP, PPP NCPs, and ARAP), use the **network** keyword.

To create a method list to enable authorization to determine if a user is allowed to run an EXEC shell, use the **exec** keyword.

To create a method list to enable authorization for specific, individual EXEC commands associated with a specific privilege level, use the **commands** keyword. (This allows you to authorize all commands associated with a specified command level from 0 to 15.)

To create a method list to enable authorization for reverse Telnet functions, use the **reverse-access** keyword.

For information about the types of authorization supported by the Cisco IOS software, refer to the “[AAA Authorization Types](#)” section of this chapter.

Authorization Methods

To have the network access server request authorization information via a TACACS+ security server, use the **aaa authorization** command with the **group tacacs+ method** keyword. For more specific information about configuring authorization using a TACACS+ security server, refer to the chapter “Configuring TACACS+.” For an example of how to enable a TACACS+ server to authorize the use of network services, including PPP and ARA, see the section “[TACACS+ Authorization Examples](#)” at the end of this chapter.

To allow users to have access to the functions they request as long as they have been authenticated, use the **aaa authorization** command with the **if-authenticated method** keyword. If you select this method, all requested functions are automatically granted to authenticated users.

There may be times when you do not want to run authorization from a particular interface or line. To stop authorization activities on designated lines or interfaces, use the **none method** keyword. If you select this method, authorization is disabled for all actions.

To select local authorization, which means that the router or access server consults its local user database to determine the functions a user is permitted to use, use the **aaa authorization** command with the **local method** keyword. The functions associated with local authorization are defined by using the **username** global configuration command. For a list of permitted functions, refer to the chapter “Configuring Authentication.”

To have the network access server request authorization via a RADIUS security server, use the **radius method** keyword. For more specific information about configuring authorization using a RADIUS security server, refer to the chapter “Configuring RADIUS.”

To have the network access server request authorization via a RADIUS security server, use the **aaa authorization** command with the **group radius method** keyword. For more specific information about configuring authorization using a RADIUS security server, refer to the chapter “Configuring RADIUS”. For an example of how to enable a RADIUS server to authorize services, see the “[RADIUS Authorization Example](#)” section at the end of this chapter.



Note

Authorization method lists for SLIP follow whatever is configured for PPP on the relevant interface. If no lists are defined and applied to a particular interface (or no PPP settings are configured), the default setting for authorization applies.

Disabling Authorization for Global Configuration Commands

The **aaa authorization** command with the keyword **commands** attempts authorization for all EXEC mode commands, including global configuration commands, associated with a specific privilege level. Because there are configuration commands that are identical to some EXEC-level commands, there can be some confusion in the authorization process. Using **no aaa authorization config-commands** stops the network access server from attempting configuration command authorization.

To disable AAA authorization for all global configuration commands, use the following command in global configuration mode:

Command	Purpose
Router(config)# no aaa authorization config-commands	Disables authorization for all global configuration commands.

Configuring Authorization for Reverse Telnet

Telnet is a standard terminal emulation protocol used for remote terminal connection. Normally, you log in to a network access server (typically through a dialup connection) and then use Telnet to access other network devices from that network access server. There are times, however, when it is necessary to establish a reverse Telnet session. In reverse Telnet sessions, the Telnet connection is established in the opposite direction—from inside a network to a network access server on the network periphery to gain access to modems or other devices connected to that network access server. Reverse Telnet is used to provide users with dialout capability by allowing them to Telnet to modem ports attached to a network access server.

It is important to control access to ports accessible through reverse Telnet. Failure to do so could, for example, allow unauthorized users free access to modems where they can trap and divert incoming calls or make outgoing calls to unauthorized destinations.

Authentication during reverse Telnet is performed through the standard AAA login procedure for Telnet. Typically the user has to provide a username and password to establish either a Telnet or reverse Telnet session. Reverse Telnet authorization provides an additional (optional) level of security by requiring authorization in addition to authentication. When enabled, reverse Telnet authorization can use RADIUS or TACACS+ to authorize whether or not this user is allowed reverse Telnet access to specific asynchronous ports, after the user successfully authenticates through the standard Telnet login procedure.

Reverse Telnet authorization offers the following benefits:

- An additional level of protection by ensuring that users engaged in reverse Telnet activities are indeed authorized to access a specific asynchronous port using reverse Telnet.
- An alternative method (other than access lists) to manage reverse Telnet authorization.

To configure a network access server to request authorization information from a TACACS+ or RADIUS server before allowing a user to establish a reverse Telnet session, use the following command in global configuration mode:

Command	Purpose
<code>Router(config)# aaa authorization reverse-access method1 [method2 ...]</code>	Configures the network access server to request authorization information before allowing a user to establish a reverse Telnet session.

This feature enables the network access server to request reverse Telnet authorization information from the security server, whether RADIUS or TACACS+. You must configure the specific reverse Telnet privileges for the user on the security server itself.

Authorization Attribute-Value Pairs

RADIUS and TACACS+ authorization both define specific rights for users by processing attributes, which are stored in a database on the security server. For both RADIUS and TACACS+, attributes are defined on the security server, associated with the user, and sent to the network access server where they are applied to the user's connection.

For a list of supported RADIUS attributes, refer to the appendix "RADIUS Attributes". For a list of supported TACACS+ AV pairs, refer to the appendix "TACACS+ Attribute-Value Pairs."

Authorization Configuration Examples

The following sections provide authorization configuration examples:

- [Named Method List Configuration Example](#)
- [TACACS+ Authorization Examples](#)
- [RADIUS Authorization Example](#)
- [Reverse Telnet Authorization Examples](#)

Named Method List Configuration Example

The following example shows how to configure a Cisco AS5300 (enabled for AAA and communication with a RADIUS security server) for AAA services to be provided by the RADIUS server. If the RADIUS server fails to respond, then the local database will be queried for authentication and authorization information, and accounting services will be handled by a TACACS+ server.

```
aaa new-model
aaa authentication login admins local
aaa authentication ppp dialins group radius local
aaa authorization network scoobee group radius local
aaa accounting network charley start-stop group radius

username root password ALongPassword

radius-server host alcatraz
radius-server key myRaDiUSpassWoRd

interface group-async 1
 group-range 1 16
 encapsulation ppp
 ppp authentication chap dialins
 ppp authorization scoobee
 ppp accounting charley

line 1 16
 autoselect ppp
 autoselect during-login
 login authentication admins
 modem dialin
```

The lines in this sample RADIUS AAA configuration are defined as follows:

- The **aaa new-model** command enables AAA network security services.
- The **aaa authentication login admins local** command defines a method list, admins, for login authentication.
- The **aaa authentication ppp dialins group radius local** command defines the authentication method list “dialins,” which specifies that RADIUS authentication then (if the RADIUS server does not respond) local authentication will be used on serial lines using PPP.
- The **aaa authorization network scoobee group radius local** command defines the network authorization method list named scoobee, which specifies that RADIUS authorization will be used on serial lines using PPP. If the RADIUS server fails to respond, then local network authorization will be performed.

- The **aaa accounting network charley start-stop group radius** command defines the network accounting method list named charley, which specifies that RADIUS accounting services (in this case, start and stop records for specific events) will be used on serial lines using PPP.
- The **username** command defines the username and password to be used for the PPP Password Authentication Protocol (PAP) caller identification.
- The **radius-server host** command defines the name of the RADIUS server host.
- The **radius-server key** command defines the shared secret text string between the network access server and the RADIUS server host.
- The **interface group-async** command selects and defines an asynchronous interface group.
- The **group-range** command defines the member asynchronous interfaces in the interface group.
- The **encapsulation ppp** command sets PPP as the encapsulation method used on the specified interfaces.
- The **ppp authentication chap dialins** command selects Challenge Handshake Authentication Protocol (CHAP) as the method of PPP authentication and applies the “dialins” method list to the specified interfaces.
- The **ppp authorization scoobee** command applies the scoobee network authorization method list to the specified interfaces.
- The **ppp accounting charley** command applies the charley network accounting method list to the specified interfaces.
- The **line** command switches the configuration mode from global configuration to line configuration and identifies the specific lines being configured.
- The **autoselect ppp** command configures the Cisco IOS software to allow a PPP session to start up automatically on these selected lines.
- The **autoselect during-login** command is used to display the username and password prompt without pressing the Return key. After the user logs in, the autoselect function (in this case, PPP) begins.
- The **login authentication admins** command applies the admins method list for login authentication.
- The **modem dialin** command configures modems attached to the selected lines to only accept incoming calls.

TACACS+ Authorization Examples

The following examples show how to use a TACACS+ server to authorize the use of network services, including PPP and ARA. If the TACACS+ server is not available or an error occurs during the authorization process, the fallback method (none) is to grant all authorization requests:

```
aaa authorization network default group tacacs+ none
```

The following example shows how to allow network authorization using TACACS+:

```
aaa authorization network default group tacacs+
```

The following example shows how to provide the same authorization, but it also creates address pools called “mci” and “att”:

```
aaa authorization network default group tacacs+
ip address-pool local
ip local-pool mci 172.16.0.1 172.16.0.255
ip local-pool att 172.17.0.1 172.17.0.255
```

These address pools can then be selected by the TACACS daemon. A sample configuration of the daemon follows:

```
user = mci_customer1 {
    login = cleartext "some password"
    service = ppp protocol = ip {
        addr-pool=mci
    }
}

user = att_customer1 {
    login = cleartext "some other password"
    service = ppp protocol = ip {
        addr-pool=att
    }
}
```

RADIUS Authorization Example

The following example shows how to configure the router to authorize using RADIUS:

```
aaa new-model
aaa authorization exec default group radius if-authenticated
aaa authorization network default group radius
radius-server host ip
radius-server key
```

The lines in this sample RADIUS authorization configuration are defined as follows:

- The **aaa authorization exec default group radius if-authenticated** command configures the network access server to contact the RADIUS server to determine if users are permitted to start an EXEC shell when they log in. If an error occurs when the network access server contacts the RADIUS server, the fallback method is to permit the CLI to start, provided the user has been properly authenticated.

The RADIUS information returned may be used to specify an autocommand or a connection access list be applied to this connection.

- The **aaa authorization network default group radius** command configures network authorization via RADIUS. This can be used to govern address assignment, the application of access lists, and various other per-user quantities.



Note

Because no fallback method is specified in this example, authorization will fail if, for any reason, there is no response from the RADIUS server.

Reverse Telnet Authorization Examples

The following examples show how to cause the network access server to request authorization information from a TACACS+ security server before allowing a user to establish a reverse Telnet session:

```
aaa new-model
aaa authentication login default group tacacs+
aaa authorization reverse-access default group tacacs+
!
tacacs-server host 172.31.255.0
tacacs-server timeout 90
tacacs-server key goaway
```

The lines in this sample TACACS+ reverse Telnet authorization configuration are defined as follows:

- The **aaa new-model** command enables AAA.
- The **aaa authentication login default group tacacs+** command specifies TACACS+ as the default method for user authentication during login.
- The **aaa authorization reverse-access default group tacacs+** command specifies TACACS+ as the method for user authorization when trying to establish a reverse Telnet session.
- The **tacacs-server host** command identifies the TACACS+ server.
- The **tacacs-server timeout** command sets the interval of time that the network access server waits for the TACACS+ server to reply.
- The **tacacs-server key** command defines the encryption key used for all TACACS+ communications between the network access server and the TACACS+ daemon.

The following example shows how to configure a generic TACACS+ server to grant a user, pat, reverse Telnet access to port tty2 on the network access server named “maple” and to port tty5 on the network access server named “oak”:

```
user = pat
login = cleartext lab
service = raccess {
    port#1 = maple/tty2
    port#2 = oak/tty5
```



Note

In this example, “maple” and “oak” are the configured host names of network access servers, not DNS names or alias.

The following example shows how to configure the TACACS+ server (CiscoSecure) to grant a user named pat reverse Telnet access:

```
user = pat
profile_id = 90
profile_cycle = 1
member = Tacacs_Users
service=shell {
    default cmd=permit
}
service=raccess {
    allow "c2511e0" "tty1" ".*"
    refuse ".*" ".*" ".*"
    password = clear "goaway"
```



Note

CiscoSecure only supports reverse Telnet using the command line interface in versions 2.1(x) through version 2.2(1).

An empty “service=raccess { }” clause permits a user to have unconditional access to network access server ports for reverse Telnet. If no “service=raccess” clause exists, the user is denied access to any port for reverse Telnet.

For more information about configuring TACACS+, refer to the chapter “Configuring TACACS+.” For more information about configuring CiscoSecure, refer to the *CiscoSecure Access Control Server User Guide*, version 2.1(2) or greater.

The following example shows how to cause the network access server to request authorization from a RADIUS security server before allowing a user to establish a reverse Telnet session:

```
aaa new-model
```

```
aaa authentication login default group radius
aaa authorization reverse-access default group radius
!
radius-server host 172.31.255.0
radius-server key go away
auth-port 1645 acct-port 1646
```

The lines in this sample RADIUS reverse Telnet authorization configuration are defined as follows:

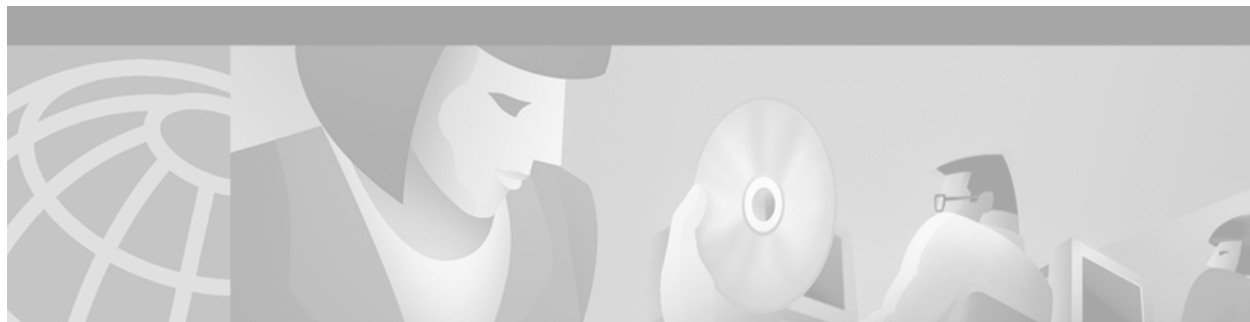
- The **aaa new-model** command enables AAA.
- The **aaa authentication login default group radius** command specifies RADIUS as the default method for user authentication during login.
- The **aaa authorization reverse-access default group radius** command specifies RADIUS as the method for user authorization when trying to establish a reverse Telnet session.
- The **radius-server host** command identifies the RADIUS server.
- The **radius-server key** command defines the encryption key used for all RADIUS communications between the network access server and the RADIUS daemon.

The following example shows how to send a request to the RADIUS server to grant a user named “pat” reverse Telnet access at port tty2 on the network access server named “maple”:

```
Username = "pat"
Password = "goaway"
User-Service-Type = Shell-User
cisco-avpair = "raccess:port#1=maple/tty2"
```

The syntax "raccess:port=any/any" permits a user to have unconditional access to network access server ports for reverse Telnet. If no "raccess:port={*nasname*}/{*tty number*}" clause exists in the user profile, the user is denied access to reverse Telnet on all ports.

For more information about configuring RADIUS, refer to the chapter “Configuring RADIUS.”



Configuring Accounting

The AAA accounting feature enables you to track the services that users are accessing and the amount of network resources that they are consuming. When AAA accounting is enabled, the network access server reports user activity to the TACACS+ or RADIUS security server (depending on which security method you have implemented) in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server. This data can then be analyzed for network management, client billing, and auditing.

For a complete description of the accounting commands used in this chapter, refer to the chapter “Accounting Commands” in the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the chapter “Identifying Supported Platforms” section in the “Using Cisco IOS Software.”

In This Chapter

This chapter contains the following sections:

- [Named Method Lists for Accounting](#)
- [AAA Accounting Types](#)
- [AAA Accounting Enhancements](#)
- [AAA Accounting Prerequisites](#)
- [AAA Accounting Configuration Task List](#)
- [Accounting Attribute-Value Pairs](#)
- [Accounting Configuration Examples](#)

Named Method Lists for Accounting

Like authentication and authorization method lists, method lists for accounting define the way accounting will be performed and the sequence in which these methods are performed.

Named accounting method lists enable you to designate a particular security protocol to be used on specific lines or interfaces for accounting services. The only exception is the default method list (which, by coincidence, is named “default”). The default method list is automatically applied to all interfaces except those that have a named method list explicitly defined. A defined method list overrides the default method list.

A method list is simply a named list describing the accounting methods to be queried (such as RADIUS or TACACS+), in sequence. Method lists enable you to designate one or more security protocols to be used for accounting, thus ensuring a backup system for accounting in case the initial method fails. Cisco IOS software uses the first method listed to support accounting; if that method fails to respond, the Cisco IOS software selects the next accounting method listed in the method list. This process continues until there is successful communication with a listed accounting method, or all methods defined are exhausted.

**Note**

The Cisco IOS software attempts accounting with the next listed accounting method only when there is no response from the previous method. If accounting fails at any point in this cycle—meaning that the security server responds by denying the user access—the accounting process stops and no other accounting methods are attempted.

Accounting method lists are specific to the type of accounting being requested. AAA supports six different types of accounting:

- **Network**—Provides information for all PPP, SLIP, or ARAP sessions, including packet and byte counts.
- **EXEC**—Provides information about user EXEC terminal sessions of the network access server.
- **Commands**—Provides information about the EXEC mode commands that a user issues. Command accounting generates accounting records for all EXEC mode commands, including global configuration commands, associated with a specific privilege level.
- **Connection**—Provides information about all outbound connections made from the network access server, such as Telnet, local-area transport (LAT), TN3270, packet assembler/disassembler (PAD), and rlogin.
- **System**—Provides information about system-level events.
- **Resource**—Provides “start” and “stop” records for calls that have passed user authentication, and provides “stop” records for calls that fail to authenticate.

**Note**

System accounting does not use named accounting lists; you can only define the default list for system accounting.

Once again, when you create a named method list, you are defining a particular list of accounting methods for the indicated accounting type.

Accounting method lists must be applied to specific lines or interfaces before any of the defined methods will be performed. The only exception is the default method list (which is named “default”). If the **aaa accounting** command for a particular accounting type is issued without a named method list specified, the default method list is automatically applied to all interfaces or lines except those that have a named method list explicitly defined. (A defined method list overrides the default method list.) If no default method list is defined, then no accounting takes place.

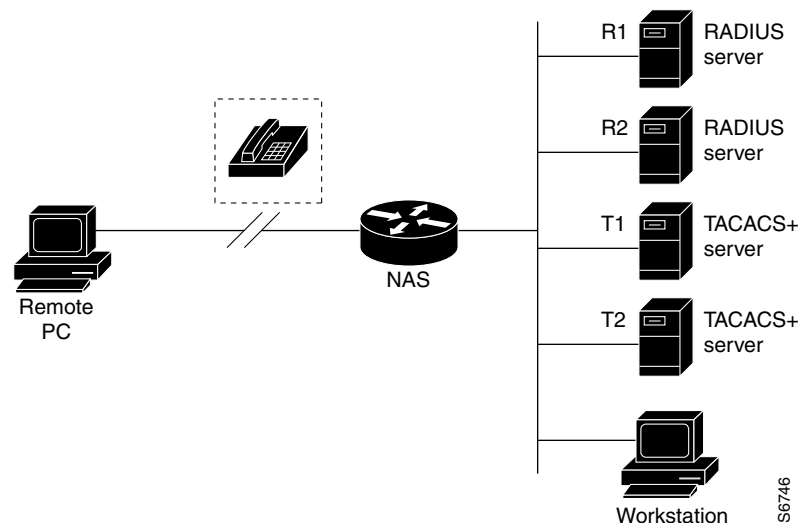
This section includes the following subsections:

- [Method Lists and Server Groups](#)
- [AAA Accounting Methods](#)

Method Lists and Server Groups

A server group is a way to group existing RADIUS or TACACS+ server hosts for use in method lists. [Figure 7](#) shows a typical AAA network configuration that includes four security servers: R1 and R2 are RADIUS servers, and T1 and T2 are TACACS+ servers. R1 and R2 comprise the group of RADIUS servers. T1 and T2 comprise the group of TACACS+ servers.

Figure 7 Typical AAA Network Configuration



In Cisco IOS software, RADIUS and TACACS+ server configurations are global. Using server groups, you can specify a subset of the configured server hosts and use them for a particular service. For example, server groups allow you to define R1 and R2 as separate server groups (SG1 and SG2), and T1 and T2 as separate server groups (SG3 and SG4). This means you can specify either R1 and T1 (SG1 and SG3) in the method list or R2 and T2 (SG2 and SG4) in the method list, which provides more flexibility in the way that you assign RADIUS and TACACS+ resources.

Server groups also can include multiple host entries for the same server, as long as each entry has a unique identifier. The combination of an IP address and a UDP port number creates a unique identifier, allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. In other words, this unique identifier enables RADIUS requests to be sent to different UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service—for example, accounting—the second host entry configured acts as failover backup to the first one. Using this example, if the first host entry fails to provide accounting services, the network access server will try the second host entry configured on the same device for accounting services. (The RADIUS host entries will be tried in the order in which they are configured.)

For more information about configuring server groups and about configuring server groups based on DNIS numbers, refer to the chapter “Configuring RADIUS” or the chapter “Configuring TACACS+.”

AAA Accounting Methods

Cisco IOS supports the following two methods for accounting:

- **TACACS+**—The network access server reports user activity to the TACACS+ security server in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server.
- **RADIUS**—The network access server reports user activity to the RADIUS security server in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server.

AAA Accounting Types

AAA supports six different accounting types:

- [Network Accounting](#)
- [Connection Accounting](#)
- [EXEC Accounting](#)
- [System Accounting](#)
- [Command Accounting](#)
- [Resource Accounting](#)

Network Accounting

Network accounting provides information for all PPP, SLIP, or ARAP sessions, including packet and byte counts.

The following example shows the information contained in a RADIUS network accounting record for a PPP user who comes in through an EXEC session:

```
Wed Jun 27 04:44:45 2001
  NAS-IP-Address = "172.16.25.15"
  NAS-Port = 5
  User-Name = "fgeorge"
  Client-Port-DNIS = "4327528"
  Caller-ID = "562"
  Acct-Status-Type = Start
  Acct-Authentic = RADIUS
  Service-Type = Exec-User
  Acct-Session-Id = "0000000D"
  Acct-Delay-Time = 0
  User-Id = "fgeorge"
  NAS-Identifier = "172.16.25.15"
```

```
Wed Jun 27 04:45:00 2001
  NAS-IP-Address = "172.16.25.15"
  NAS-Port = 5
  User-Name = "fgeorge"
  Client-Port-DNIS = "4327528"
  Caller-ID = "562"
  Acct-Status-Type = Start
  Acct-Authentic = RADIUS
  Service-Type = Framed
```

```

Acct-Session-Id = "0000000E"
Framed-IP-Address = "10.1.1.2"
Framed-Protocol = PPP
Acct-Delay-Time = 0
User-Id = "fgeorge"
NAS-Identifier = "172.16.25.15"

Wed Jun 27 04:47:46 2001
NAS-IP-Address = "172.16.25.15"
NAS-Port = 5
User-Name = "fgeorge"
Client-Port-DNIS = "4327528"
Caller-ID = "562"
Acct-Status-Type = Stop
Acct-Authentic = RADIUS
Service-Type = Framed
Acct-Session-Id = "0000000E"
Framed-IP-Address = "10.1.1.2"
Framed-Protocol = PPP
Acct-Input-Octets = 3075
Acct-Output-Octets = 167
Acct-Input-Packets = 39
Acct-Output-Packets = 9
Acct-Session-Time = 171
Acct-Delay-Time = 0
User-Id = "fgeorge"
NAS-Identifier = "172.16.25.15"

Wed Jun 27 04:48:45 2001
NAS-IP-Address = "172.16.25.15"
NAS-Port = 5
User-Name = "fgeorge"
Client-Port-DNIS = "4327528"
Caller-ID = "408"
Acct-Status-Type = Stop
Acct-Authentic = RADIUS
Service-Type = Exec-User
Acct-Session-Id = "0000000D"
Acct-Delay-Time = 0
User-Id = "fgeorge"
NAS-Identifier = "172.16.25.15"

```

The following example shows the information contained in a TACACS+ network accounting record for a PPP user who first started an EXEC session:

```

Wed Jun 27 04:00:35 2001 172.16.25.15 fgeorge tty4 562/4327528 starttask_id=28
service=shell
Wed Jun 27 04:00:46 2001 172.16.25.15 fgeorge tty4 562/4327528 starttask_id=30
addr=10.1.1.1 service=ppp
Wed Jun 27 04:00:49 2001 172.16.25.15 fgeorge tty4 408/4327528 update
task_id=30 addr=10.1.1.1 service=ppp protocol=ip addr=10.1.1.1
Wed Jun 27 04:01:31 2001 172.16.25.15 fgeorge tty4 562/4327528 stoptask_id=30
addr=10.1.1.1 service=ppp protocol=ip addr=10.1.1.1 bytes_in=2844
bytes_out=1682 paks_in=36 paks_out=24 elapsed_time=51
Wed Jun 27 04:01:32 2001 172.16.25.15 fgeorge tty4 562/4327528 stoptask_id=28
service=shell elapsed_time=57

```



Note

The precise format of accounting packets records may vary depending on your particular security server daemon.

The following example shows the information contained in a RADIUS network accounting record for a PPP user who comes in through autoselect:

```
Wed Jun 27 04:30:52 2001
  NAS-IP-Address = "172.16.25.15"
  NAS-Port = 3
  User-Name = "fgeorge"
  Client-Port-DNIS = "4327528"
  Caller-ID = "562"
  Acct-Status-Type = Start
  Acct-Authentic = RADIUS
  Service-Type = Framed
  Acct-Session-Id = "0000000B"
  Framed-Protocol = PPP
  Acct-Delay-Time = 0
  User-Id = "fgeorge"
  NAS-Identifier = "172.16.25.15"
```

```
Wed Jun 27 04:36:49 2001
  NAS-IP-Address = "172.16.25.15"
  NAS-Port = 3
  User-Name = "fgeorge"
  Client-Port-DNIS = "4327528"
  Caller-ID = "562"
  Acct-Status-Type = Stop
  Acct-Authentic = RADIUS
  Service-Type = Framed
  Acct-Session-Id = "0000000B"
  Framed-Protocol = PPP
  Framed-IP-Address = "10.1.1.1"
  Acct-Input-Octets = 8630
  Acct-Output-Octets = 5722
  Acct-Input-Packets = 94
  Acct-Output-Packets = 64
  Acct-Session-Time = 357
  Acct-Delay-Time = 0
  User-Id = "fgeorge"
  NAS-Identifier = "172.16.25.15"
```

The following example shows the information contained in a TACACS+ network accounting record for a PPP user who comes in through autoselect:

```
Wed Jun 27 04:02:19 2001 172.16.25.15 fgeorge Async5 562/4327528 starttask_id=35
service=ppp
Wed Jun 27 04:02:25 2001 172.16.25.15 fgeorge Async5 562/4327528 update
task_id=35 service=ppp protocol=ip addr=10.1.1.2
Wed Jun 27 04:05:03 2001 172.16.25.15 fgeorge Async5 562/4327528 stoptask_id=35
service=ppp protocol=ip addr=10.1.1.2 bytes_in=3366 bytes_out=2149
paks_in=42 paks_out=28 elapsed_time=164
```

Connection Accounting

Connection accounting provides information about all outbound connections made from the network access server, such as Telnet, local-area transport (LAT), TN3270, packet assembler/disassembler (PAD), and rlogin.

The following example shows the information contained in a RADIUS connection accounting record for an outbound Telnet connection:

```
Wed Jun 27 04:28:00 2001
  NAS-IP-Address = "172.16.25.15"
  NAS-Port = 2
  User-Name = "fgeorge"
  Client-Port-DNIS = "4327528"
  Caller-ID = "5622329477"
  Acct-Status-Type = Start
  Acct-Authentic = RADIUS
  Service-Type = Login
  Acct-Session-Id = "00000008"
  Login-Service = Telnet
  Login-IP-Host = "171.68.202.158"
  Acct-Delay-Time = 0
  User-Id = "fgeorge"
  NAS-Identifier = "172.16.25.15"
```

```
Wed Jun 27 04:28:39 2001
  NAS-IP-Address = "172.16.25.15"
  NAS-Port = 2
  User-Name = "fgeorge"
  Client-Port-DNIS = "4327528"
  Caller-ID = "5622329477"
  Acct-Status-Type = Stop
  Acct-Authentic = RADIUS
  Service-Type = Login
  Acct-Session-Id = "00000008"
  Login-Service = Telnet
  Login-IP-Host = "171.68.202.158"
  Acct-Input-Octets = 10774
  Acct-Output-Octets = 112
  Acct-Input-Packets = 91
  Acct-Output-Packets = 99
  Acct-Session-Time = 39
  Acct-Delay-Time = 0
  User-Id = "fgeorge"
  NAS-Identifier = "172.16.25.15"
```

The following example shows the information contained in a TACACS+ connection accounting record for an outbound Telnet connection:

```
Wed Jun 27 03:47:43 2001      172.16.25.15      fgeorge      tty3      5622329430/4327528
start      task_id=10      service=connection      protocol=telnet addr=171.68.202.158
cmd=telnet fgeorge-sun
Wed Jun 27 03:48:38 2001      172.16.25.15      fgeorge      tty3      5622329430/4327528 stop
task_id=10      service=connection      protocol=telnet addr=171.68.202.158 cmd=telnet
fgeorge-sun      bytes_in=4467      bytes_out=96      paks_in=61      paks_out=72
elapsed_time=55
```

The following example shows the information contained in a RADIUS connection accounting record for an outbound rlogin connection:

```
Wed Jun 27 04:29:48 2001
  NAS-IP-Address = "172.16.25.15"
  NAS-Port = 2
```

```

User-Name = "fgeorge"
Client-Port-DNIS = "4327528"
Caller-ID = "5622329477"
Acct-Status-Type = Start
Acct-Authentic = RADIUS
Service-Type = Login
Acct-Session-Id = "0000000A"
Login-Service = Rlogin
Login-IP-Host = "171.68.202.158"
Acct-Delay-Time = 0
User-Id = "fgeorge"
NAS-Identifier = "172.16.25.15"

```

```

Wed Jun 27 04:30:09 2001
NAS-IP-Address = "172.16.25.15"
NAS-Port = 2
User-Name = "fgeorge"
Client-Port-DNIS = "4327528"
Caller-ID = "5622329477"
Acct-Status-Type = Stop
Acct-Authentic = RADIUS
Service-Type = Login
Acct-Session-Id = "0000000A"
Login-Service = Rlogin
Login-IP-Host = "171.68.202.158"
Acct-Input-Octets = 18686
Acct-Output-Octets = 86
Acct-Input-Packets = 90
Acct-Output-Packets = 68
Acct-Session-Time = 22
Acct-Delay-Time = 0
User-Id = "fgeorge"
NAS-Identifier = "172.16.25.15"

```

The following example shows the information contained in a TACACS+ connection accounting record for an outbound rlogin connection:

```

Wed Jun 27 03:48:46 2001      172.16.25.15      fgeorge      tty3      5622329430/4327528
start      task_id=12      service=connection      protocol=rlogin      addr=171.68.202.158
cmd=rlogin fgeorge-sun /user fgeorge
Wed Jun 27 03:51:37 2001      172.16.25.15      fgeorge      tty3      5622329430/4327528 stop
task_id=12      service=connection      protocol=rlogin      addr=171.68.202.158 cmd=rlogin
fgeorge-sun /user fgeorge bytes_in=659926 bytes_out=138 paks_in=2378 paks_
out=1251      elapsed_time=171

```

The following example shows the information contained in a TACACS+ connection accounting record for an outbound LAT connection:

```

Wed Jun 27 03:53:06 2001      172.16.25.15      fgeorge      tty3      5622329430/4327528
start      task_id=18      service=connection      protocol=lat      addr=VAX      cmd=lat
VAX
Wed Jun 27 03:54:15 2001      172.16.25.15      fgeorge      tty3      5622329430/4327528 stop
task_id=18      service=connection      protocol=lat      addr=VAX      cmd=lat VAX
bytes_in=0      bytes_out=0      paks_in=0      paks_out=0      elapsed_time=6

```


EXEC Accounting

EXEC accounting provides information about user EXEC terminal sessions (user shells) on the network access server, including username, date, start and stop times, the access server IP address, and (for dial-in users) the telephone number the call originated from.

The following example shows the information contained in a RADIUS EXEC accounting record for a dial-in user:

```
Wed Jun 27 04:26:23 2001
  NAS-IP-Address = "172.16.25.15"
  NAS-Port = 1
  User-Name = "fgeorge"
  Client-Port-DNIS = "4327528"
  Caller-ID = "5622329483"
  Acct-Status-Type = Start
  Acct-Authentic = RADIUS
  Service-Type = Exec-User
  Acct-Session-Id = "00000006"
  Acct-Delay-Time = 0
  User-Id = "fgeorge"
  NAS-Identifier = "172.16.25.15"
```

```
Wed Jun 27 04:27:25 2001
  NAS-IP-Address = "172.16.25.15"
  NAS-Port = 1
  User-Name = "fgeorge"
  Client-Port-DNIS = "4327528"
  Caller-ID = "5622329483"
  Acct-Status-Type = Stop
  Acct-Authentic = RADIUS
  Service-Type = Exec-User
  Acct-Session-Id = "00000006"
  Acct-Session-Time = 62
  Acct-Delay-Time = 0
  User-Id = "fgeorge"
  NAS-Identifier = "172.16.25.15"
```

The following example shows the information contained in a TACACS+ EXEC accounting record for a dial-in user:

```
Wed Jun 27 03:46:21 2001      172.16.25.15      fgeorge      tty3      5622329430/4327528
start      task_id=2      service=shell
Wed Jun 27 04:08:55 2001      172.16.25.15      fgeorge      tty3      5622329430/4327528      stop
task_id=2      service=shell      elapsed_time=1354
```

The following example shows the information contained in a RADIUS EXEC accounting record for a Telnet user:

```
Wed Jun 27 04:48:32 2001
  NAS-IP-Address = "172.16.25.15"
  NAS-Port = 26
  User-Name = "fgeorge"
  Caller-ID = "171.68.202.158"
  Acct-Status-Type = Start
  Acct-Authentic = RADIUS
  Service-Type = Exec-User
  Acct-Session-Id = "00000010"
  Acct-Delay-Time = 0
  User-Id = "fgeorge"
  NAS-Identifier = "172.16.25.15"
```

```

Wed Jun 27 04:48:46 2001
  NAS-IP-Address = "172.16.25.15"
  NAS-Port = 26
  User-Name = "fgeorge"
  Caller-ID = "171.68.202.158"
  Acct-Status-Type = Stop
  Acct-Authentic = RADIUS
  Service-Type = Exec-User
  Acct-Session-Id = "00000010"
  Acct-Session-Time = 14
  Acct-Delay-Time = 0
  User-Id = "fgeorge"
  NAS-Identifier = "172.16.25.15"

```

The following example shows the information contained in a TACACS+ EXEC accounting record for a Telnet user:

```

Wed Jun 27 04:06:53 2001      172.16.25.15      fgeorge      tty26      171.68.202.158
starttask_id=41      service=shell
Wed Jun 27 04:07:02 2001      172.16.25.15      fgeorge      tty26      171.68.202.158
stoptask_id=41      service=shell      elapsed_time=9

```

System Accounting

System accounting provides information about all system-level events (for example, when the system reboots or when accounting is turned on or off).

The following accounting record shows a typical TACACS+ system accounting record server indicating that AAA accounting has been turned off:

```

Wed Jun 27 03:55:32 2001      172.16.25.15      unknown unknown unknown start      task_id=25
service=system      event=sys_acct      reason=reconfigure

```



Note

The precise format of accounting packets records may vary depending on your particular TACACS+ daemon.

The following accounting record shows a TACACS+ system accounting record indicating that AAA accounting has been turned on:

```

Wed Jun 27 03:55:22 2001      172.16.25.15      unknown unknown unknown stop      task_id=23
service=system      event=sys_acct      reason=reconfigure

```

Additional tasks for measuring system resources are covered in other chapters in the Cisco IOS software configuration guides. For example, IP accounting tasks are described in the “Configuring IP Services” chapter in the *Cisco IOS IP Configuration Guide*.

Command Accounting

Command accounting provides information about the EXEC shell commands for a specified privilege level that are being executed on a network access server. Each command accounting record includes a list of the commands executed for that privilege level, as well as the date and time each command was executed, and the user who executed it.

The following example shows the information contained in a TACACS+ command accounting record for privilege level 1:

```
Wed Jun 27 03:46:47 2001      172.16.25.15      fgeorge  tty3      5622329430/4327528  stop
task_id=3      service=shell  priv-lvl=1      cmd=show version <cr>
Wed Jun 27 03:46:58 2001      172.16.25.15      fgeorge  tty3      5622329430/4327528  stop
task_id=4      service=shell  priv-lvl=1      cmd=show interfaces Ethernet 0 <cr>
Wed Jun 27 03:47:03 2001      172.16.25.15      fgeorge  tty3      5622329430/4327528  stop
task_id=5      service=shell  priv-lvl=1      cmd=show ip route <cr>
```

The following example shows the information contained in a TACACS+ command accounting record for privilege level 15:

```
Wed Jun 27 03:47:17 2001      172.16.25.15      fgeorge  tty3      5622329430/4327528  stop
task_id=6      service=shell  priv-lvl=15     cmd=configure terminal <cr>
Wed Jun 27 03:47:21 2001      172.16.25.15      fgeorge  tty3      5622329430/4327528  stop
task_id=7      service=shell  priv-lvl=15     cmd=interface Serial 0 <cr>
Wed Jun 27 03:47:29 2001      172.16.25.15      fgeorge  tty3      5622329430/4327528  stop
task_id=8      service=shell  priv-lvl=15     cmd=ip address 1.1.1.1 255.255.255.0 <cr>
```



Note

The Cisco Systems implementation of RADIUS does not support command accounting.

Resource Accounting

The Cisco implementation of AAA accounting provides “start” and “stop” record support for calls that have passed user authentication. The additional feature of generating “stop” records for calls that fail to authenticate as part of user authentication is also supported. Such records are necessary for users employing accounting records to manage and monitor their networks.

This section includes the following subsections:

- [AAA Resource Failure Stop Accounting](#)
- [AAA Resource Accounting for Start-Stop Records](#)

AAA Resource Failure Stop Accounting

Before AAA resource failure stop accounting, there was no method of providing accounting records for calls that failed to reach the user authentication stage of a call setup sequence. Such records are necessary for users employing accounting records to manage and monitor their networks and their wholesale customers.

This functionality will generate a “stop” accounting record for any calls that do not reach user authentication; “stop” records will be generated from the moment of call setup. All calls that pass user authentication will behave as before; that is, no additional accounting records will be seen.



Note

For Cisco IOS Release 12.2, this function is supported only on the Cisco AS5300 and Cisco AS5800.

Figure 8 illustrates a call setup sequence with normal call flow (no disconnect) and without AAA resource failure stop accounting enabled.

Figure 8 Modem Dial-In Call Setup Sequence With Normal Flow and Without Resource Failure Stop Accounting Enabled

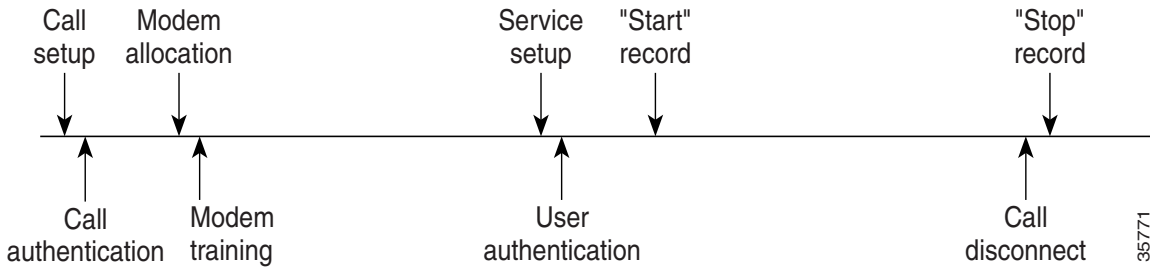


Figure 9 illustrates a call setup sequence with normal call flow (no disconnect) and with AAA resource failure stop accounting enabled.

Figure 9 Modem Dial-In Call Setup Sequence With Normal Flow and With Resource Failure Stop Accounting Enabled

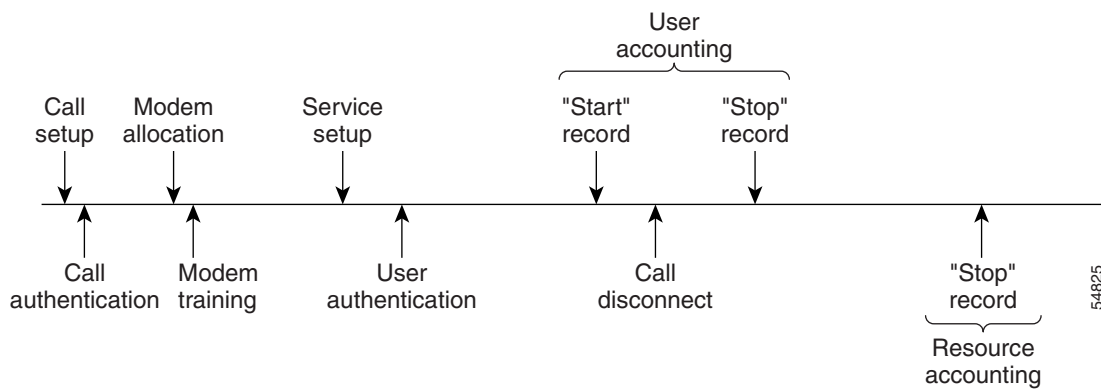


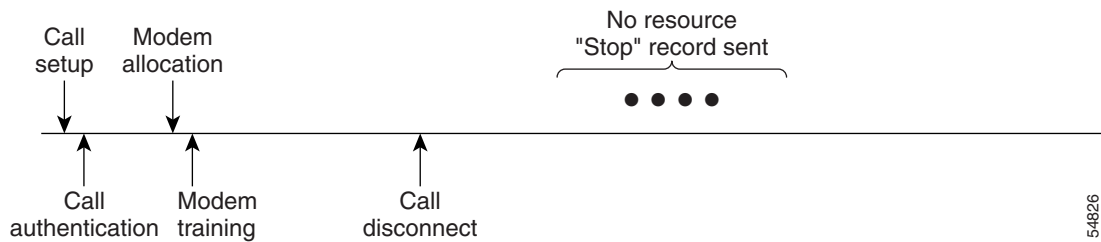
Figure 10 illustrates a call setup sequence with call disconnect occurring before user authentication and with AAA resource failure stop accounting enabled.

Figure 10 Modem Dial-In Call Setup Sequence With Call Disconnect Occurring Before User Authentication and With Resource Failure Stop Accounting Enabled



Figure 11 illustrates a call setup sequence with call disconnect occurring before user authentication and without AAA resource failure stop accounting enabled.

Figure 11 *Modem Dial-In Call Setup Sequence With Call Disconnect Occurring Before User Authentication and Without Resource Failure Stop Accounting Enabled*



AAA Resource Accounting for Start-Stop Records

AAA resource accounting for start-stop records supports the ability to send a “start” record at each call setup, followed by a corresponding “stop” record at the call disconnect. This functionality can be used to manage and monitor wholesale customers from one source of data reporting, such as accounting records.

With this feature, a call setup and call disconnect “start-stop” accounting record tracks the progress of the resource connection to the device. A separate user authentication “start-stop” accounting record tracks the user management progress. These two sets of accounting records are interlinked by using a unique session ID for the call.

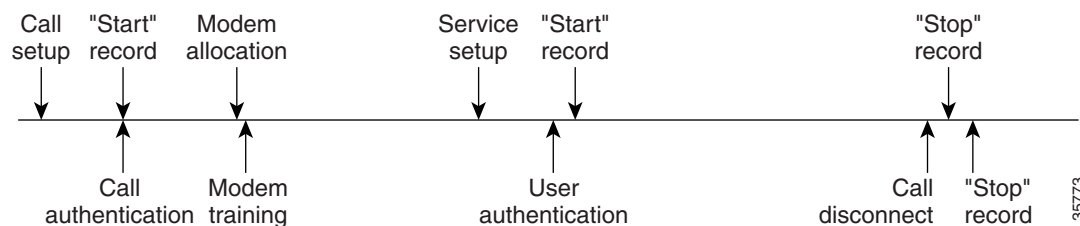


Note

For Cisco IOS Release 12.2, this function is supported only on the Cisco AS5300 and Cisco AS5800.

Figure 12 illustrates a call setup sequence with AAA resource start-stop accounting enabled.

Figure 12 *Modem Dial-In Call Setup Sequence With Resource Start-Stop Accounting Enabled*



AAA Accounting Enhancements

The section includes the following enhancements:

- [AAA Broadcast Accounting](#)
- [AAA Session MIB](#)

AAA Broadcast Accounting

AAA broadcast accounting allows accounting information to be sent to multiple AAA servers at the same time; that is, accounting information can be broadcast to one or more AAA servers simultaneously. This functionality allows service providers to send accounting information to their own private AAA servers and to the AAA servers of their end customers. It also provides redundant billing information for voice applications.

Restrictions

- Accounting information can be sent simultaneously to a maximum of four AAA servers.
- SSG Restriction—For SSG systems, the **aaa accounting network broadcast** command broadcasts only **start-stop** accounting records. If interim accounting records are configured using the **ssg accounting interval** command, the interim accounting records are sent only to the configured default RADIUS server.

Broadcasting is allowed among groups of RADIUS or TACACS+ servers, and each server group can define its backup servers for failover independently of other groups.

Thus, service providers and their end customers can use different protocols (RADIUS or TACACS+) for the accounting server. Service providers and their end customers can also specify their backup servers independently. As for voice applications, redundant accounting information can be managed independently through a separate group with its own failover sequence.

AAA Session MIB

The AAA session MIB feature allows customers to monitor and terminate their authenticated client connections using Simple Network Management Protocol (SNMP). The data of the client is presented so that it correlates directly to the AAA accounting information reported by either the RADIUS or the TACACS+ server. AAA session MIB provides the following information:

- Statistics for each AAA function (when used in conjunction with the **show radius statistics** command)
- Status of servers providing AAA functions
- Identities of external AAA servers
- Real-time information (such as idle times), providing additional criteria for use by SNMP networks for assessing whether or not to terminate an active call



Note

This command is supported only on Cisco AS5300 and Cisco AS5800 universal access server platforms.

[Table 10](#) shows the SNMP user-end data objects that can be used to monitor and terminate authenticated client connections with the AAA session MIB feature.

Table 10 *SNMP End-User Data Objects*

SessionId	The session identification used by the AAA accounting protocol (same value as reported by RADIUS attribute 44 (Acct-Session-ID)).
UserId	The user login ID or zero-length string if a login is unavailable.
IpAddr	The IP address of the session or 0.0.0.0 if an IP address is not applicable or unavailable.

Table 10 *SNMP End-User Data Objects (continued)*

IdleTime	The elapsed time in seconds that the session has been idle.
Disconnect	The session termination object used to disconnect the given client.
CallId	The entry index corresponding to this accounting session that the Call Tracker record stored.

[Table 11](#) describes the AAA summary information provided by the AAA session MIB feature using SNMP on a per-system basis.

Table 11 *SNMP AAA Session Summary*

ActiveTableEntries	Number of sessions currently active.
ActiveTableHighWaterMark	Maximum number of sessions present at once since last system reinstallation.
TotalSessions	Total number of sessions since last system reinstallation.
DisconnectedSessions	Total number of sessions that have been disconnected using since last system reinstallation.

AAA Accounting Prerequisites

Before configuring accounting using named method lists, you must first perform the following tasks:

- Enable AAA on your network access server. For more information about enabling AAA on your Cisco router or access server, refer to the chapter “AAA Overview”.
- Define the characteristics of your RADIUS or TACACS+ security server if you are issuing RADIUS or TACACS+ authorization. For more information about configuring your Cisco network access server to communicate with your RADIUS security server, refer to the chapter “Configuring RADIUS”. For more information about configuring your Cisco network access server to communicate with your TACACS+ security server, refer to the chapter “Configuring TACACS+”.

AAA Accounting Configuration Task List

This section describes the following configuration tasks:

- [Configuring AAA Accounting Using Named Method Lists](#)
- [Suppressing Generation of Accounting Records for Null Username Sessions](#)
- [Generating Interim Accounting Records](#)
- [Generating Accounting Records for Failed Login or Session](#)
- [Specifying Accounting NETWORK-Stop Records Before EXEC-Stop Records](#)
- [Configuring AAA Resource Failure Stop Accounting](#)
- [Configuring AAA Resource Accounting for Start-Stop Records](#)
- [Configuring AAA Broadcast Accounting](#)
- [Configuring AAA Resource Failure Stop Accounting](#)

- [Configuring AAA Session MIB](#)
- [Monitoring Accounting](#)
- [Troubleshooting Accounting](#)

For accounting configuration examples using the commands in this chapter, refer to the section [“Accounting Configuration Examples”](#) at the end of the this chapter.

Configuring AAA Accounting Using Named Method Lists

To configure AAA accounting using named method lists, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa accounting { system network exec connection commands <i>level</i> } { default <i>list-name</i> } { start-stop stop-only none } [<i>method1</i> [<i>method2</i> ...]]	Creates an accounting method list and enables accounting. The argument <i>list-name</i> is a character string used to name the list you are creating.
Step 2	Router(config)# line [aux console tty vty] <i>line-number</i> [<i>ending-line-number</i>] or Router(config)# interface <i>interface-type</i> <i>interface-number</i>	Enters the line configuration mode for the lines to which you want to apply the accounting method list. or Enters the interface configuration mode for the interfaces to which you want to apply the accounting method list.
Step 3	Router(config-line)# accounting { arap commands <i>level</i> connection exec } { default <i>list-name</i> } or Router(config-if)# ppp accounting { default <i>list-name</i> }	Applies the accounting method list to a line or set of lines. or Applies the accounting method list to an interface or set of interfaces.



Note

System accounting does not use named method lists. For system accounting, you can define only the default method list.

This section includes the following sections:

- [Accounting Types](#)
- [Accounting Record Types](#)
- [Accounting Methods](#)

Accounting Types

Named accounting method lists are specific to the indicated type of accounting.

- **network**—To create a method list to enable authorization for all network-related service requests (including SLIP, PPP, PPP NCPs, and ARA protocols), use the **network** keyword. For example, to create a method list that provides accounting information for ARAP (network) sessions, use the **arap** keyword.

- **exec**—To create a method list that provides accounting records about user EXEC terminal sessions on the network access server, including username, date, start and stop times, use the **exec** keyword.
- **commands**—To create a method list that provides accounting information about specific, individual EXEC commands associated with a specific privilege level, use the **commands** keyword.
- **connection**—To create a method list that provides accounting information about all outbound connections made from the network access server, use the **connection** keyword.
- **resource**—Creates a method list to provide accounting records for calls that have passed user authentication or calls that failed to be authenticated.

**Note**

System accounting does not support named method lists.

Accounting Record Types

For minimal accounting, use the **stop-only** keyword, which instructs the specified method (RADIUS or TACACS+) to send a stop record accounting notice at the end of the requested user process. For more accounting information, use the **start-stop** keyword to send a start accounting notice at the beginning of the requested event and a stop accounting notice at the end of the event. To stop all accounting activities on this line or interface, use the **none** keyword.

Accounting Methods

Table 12 lists the supported accounting methods.

Table 12 *AAA Accounting Methods*

Keyword	Description
group radius	Uses the list of all RADIUS servers for accounting.
group tacacs+	Uses the list of all TACACS+ servers for accounting.
group <i>group-name</i>	Uses a subset of RADIUS or TACACS+ servers for accounting as defined by the server group <i>group-name</i> .

The method argument refers to the actual method the authentication algorithm tries. Additional methods of authentication are used only if the previous method returns an error, not if it fails. To specify that the authentication should succeed even if all other methods return an error, specify additional methods in the command. For example, to create a method list named `acct_tac1` that specifies RADIUS as the backup method of authentication in the event that TACACS+ authentication returns an error, enter the following command:

```
aaa accounting network acct_tac1 stop-only group tacacs+ group radius
```

To create a default list that is used when a named list is *not* specified in the **aaa accounting** command, use the **default** keyword followed by the methods you want used in default situations. The default method list is automatically applied to all interfaces.

For example, to specify RADIUS as the default method for user authentication during login, enter the following command:

```
aaa accounting network default stop-only group radius
```

AAA accounting supports the following methods:

- **group tacacs**—To have the network access server send accounting information to a TACACS+ security server, use the **group tacacs+ method** keyword. For more specific information about configuring TACACS+ for accounting services, refer to the chapter “Configuring TACACS+”.
- **group radius**—To have the network access server send accounting information to a RADIUS security server, use the **group radius method** keyword. For more specific information about configuring RADIUS for accounting services, refer to the chapter “Configuring RADIUS”.



Note

Accounting method lists for SLIP follow whatever is configured for PPP on the relevant interface. If no lists are defined and applied to a particular interface (or no PPP settings are configured), the default setting for accounting applies.

- **group group-name**—To specify a subset of RADIUS or TACACS+ servers to use as the accounting method, use the **aaa accounting** command with the **group group-name method**. To specify and define the group name and the members of the group, use the **aaa group server** command. For example, use the **aaa group server** command to first define the members of **group loginrad**:

```
aaa group server radius loginrad
  server 172.16.2.3
  server 172.16.2.17
  server 172.16.2.32
```

This command specifies RADIUS servers 172.16.2.3, 172.16.2.17, and 172.16.2.32 as members of the group **loginrad**.

To specify **group loginrad** as the method of network accounting when no other method list has been defined, enter the following command:

```
aaa accounting network default start-stop group loginrad
```

Before you can use a group name as the accounting method, you need to enable communication with the RADIUS or TACACS+ security server. For more information about establishing communication with a RADIUS server, refer to the chapter “Configuring RADIUS”. For more information about establishing communication with a TACACS+ server, refer to the chapter “Configuring TACACS+”.

Suppressing Generation of Accounting Records for Null Username Sessions

When AAA accounting is activated, the Cisco IOS software issues accounting records for all users on the system, including users whose username string, because of protocol translation, is NULL. An example of this is users who come in on lines where the **aaa authentication login method-list none** command is applied. To prevent accounting records from being generated for sessions that do not have usernames associated with them, use the following command in global configuration mode:

Command	Purpose
Router(config)# aaa accounting suppress null-username	Prevents accounting records from being generated for users whose username string is NULL.

Generating Interim Accounting Records

To enable periodic interim accounting records to be sent to the accounting server, use the following command in global configuration mode:

Command	Purpose
Router(config)# aaa accounting update {[newinfo] [periodic] number}	Enables periodic interim accounting records to be sent to the accounting server.

When the **aaa accounting update** command is activated, the Cisco IOS software issues interim accounting records for all users on the system. If the keyword **newinfo** is used, interim accounting records will be sent to the accounting server every time there is new accounting information to report. An example of this would be when IPCP completes IP address negotiation with the remote peer. The interim accounting record will include the negotiated IP address used by the remote peer.

When used with the keyword **periodic**, interim accounting records are sent periodically as defined by the argument number. The interim accounting record contains all of the accounting information recorded for that user up to the time the interim accounting record is sent.



Caution

Using the **aaa accounting update periodic** command can cause heavy congestion when many users are logged in to the network.

Generating Accounting Records for Failed Login or Session

When AAA accounting is activated, the Cisco IOS software does not generate accounting records for system users who fail login authentication, or who succeed in login authentication but fail PPP negotiation for some reason.

To specify that accounting stop records be generated for users who fail to authenticate at login or during session negotiation, use the following command in global configuration mode:

Command	Purpose
Router(config)# aaa accounting send stop-record authentication failure	Generates “stop” records for users who fail to authenticate at login or during session negotiation using PPP.

Specifying Accounting NETWORK-Stop Records Before EXEC-Stop Records

For PPP users who start EXEC terminal sessions, you can specify that NETWORK records be generated before EXEC-stop records. In some cases, such as billing customers for specific services, it can be desirable to keep network start and stop records together, essentially “nesting” them within the framework of the EXEC start and stop messages. For example, a user dialing in using PPP can create the following records: EXEC-start, NETWORK-start, EXEC-stop, NETWORK-stop. By nesting the accounting records, NETWORK-stop records follow NETWORK-start messages: EXEC-start, NETWORK-start, NETWORK-stop, EXEC-stop.

To nest accounting records for user sessions, use the following command in global configuration mode:

Command	Purpose
Router(config)# aaa accounting nested	Nests network accounting records.

Configuring AAA Resource Failure Stop Accounting

To enable resource failure stop accounting, use the following command in global configuration:

Command	Purpose
Router(config)# aaa accounting resource <i>method-list stop-failure group server-group</i>	<p>Generates a “stop” record for any calls that do not reach user authentication.</p> <p>Note Before configuring this feature, you must first perform the tasks described in the section “AAA Accounting Prerequisites” and enable Simple Network Management Protocol on your network access server. For more information about enabling SNMP on your Cisco router or access server, refer to the chapter “Configuring SNMP” of the <i>Cisco IOS Configuration Fundamentals Configuration Guide</i>.</p>

Configuring AAA Resource Accounting for Start-Stop Records

To enable full resource accounting for start-stop records, use the following command in global configuration mode:

Command	Purpose
Router(config)# aaa accounting resource <i>method-list start-stop group server-group</i>	<p>Supports the ability to send a “start” record at each call setup, followed with a corresponding “stop” record at the call disconnect.</p> <p>Note Before configuring this feature, you must first perform the tasks described in “AAA Accounting Prerequisites” and enable Simple Network Management Protocol on your network access server. For more information about enabling SNMP on your Cisco router or access server, refer to the chapter “Configuring SNMP” chapter of the <i>Cisco IOS Configuration Fundamentals Configuration Guide</i>.</p>

Configuring AAA Broadcast Accounting

To configure AAA broadcast accounting, use the **aaa accounting** command in global configuration mode. This command has been modified to allow the **broadcast** keyword.

Command	Purpose
Router(config)# aaa accounting { system network exec connection commands level } { default <i>list-name</i> } { start-stop stop-only none } [broadcast] <i>method1</i> [<i>method2...</i>]	Enables sending accounting records to multiple AAA servers. Simultaneously sends accounting records to the first server in each group. If the first server is unavailable, failover occurs using the backup servers defined within that group.

Configuring Per-DNIS AAA Broadcast Accounting

To configure AAA broadcast accounting per Dialed Number Identification Service (DNIS), use the **aaa dnis map accounting network** command in global configuration mode. This command has been modified to allow the **broadcast** keyword and multiple server groups.

Command	Purpose
Router(config)# aaa dnis map <i>dnis-number</i> accounting network [start-stop stop-only none] [broadcast] <i>method1</i> [<i>method2...</i>]	Allows per-DNIS accounting configuration. This command has precedence over the global aaa accounting command. Enables sending accounting records to multiple AAA servers. Simultaneously sends accounting records to the first server in each group. If the first server is unavailable, failover occurs using the backup servers defined within that group.

Configuring AAA Session MIB

Before configuring the AAA session MIB feature, you must perform the following tasks:

- Configure SNMP. For information on SNMP, see the chapter “Configuring SNMP Support” of the *Cisco IOS Configuration Fundamentals Configuration Guide*.
- Configure AAA.
- Define the characteristics of your RADIUS or TACACS+ server.



Note

Overusing SNMP can affect the overall performance of your system; therefore, normal network management performance must be considered when this feature is used.

To configure AAA session MIB, use the following command in global configuration mode

:

	Command	Purpose
Step 1	Router(config)# aaa session-mib disconnect	Monitors and terminates authenticated client connections using SNMP. To terminate the call, the disconnect keyword must be used.

Monitoring Accounting

No specific **show** command exists for either RADIUS or TACACS+ accounting. To obtain accounting records displaying information about users currently logged in, use the following command in privileged EXEC mode:

Command	Purpose
Router# show accounting	Allows display of the active accountable events on the network and helps collect information in the event of a data loss on the accounting server.

Troubleshooting Accounting

To troubleshoot accounting information, use the following command in privileged EXEC mode:

Command	Purpose
Router# debug aaa accounting	Displays information on accountable events as they occur.

Accounting Attribute-Value Pairs

The network access server monitors the accounting functions defined in either TACACS+ attribute-value (AV) pairs or RADIUS attributes, depending on which security method you have implemented. For a list of supported RADIUS accounting attributes, refer to the appendix “RADIUS Attributes.” For a list of supported TACACS+ accounting AV pairs, refer to the appendix “TACACS+ Attribute-Value Pairs.”

Accounting Configuration Examples

This section contains the following examples:

- [Configuring Named Method List Example](#)
- [Configuring AAA Resource Accounting](#)
- [Configuring AAA Broadcast Accounting Example](#)
- [Configuring Per-DNIS AAA Broadcast Accounting Example](#)
- [AAA Session MIB Example](#)

Configuring Named Method List Example

The following example shows how to configure a Cisco AS5200 (enabled for AAA and communication with a RADIUS security server) in order for AAA services to be provided by the RADIUS server. If the RADIUS server fails to respond, then the local database will be queried for authentication and authorization information, and accounting services will be handled by a TACACS+ server.

```
aaa new-model
aaa authentication login admins local
aaa authentication ppp dialins group radius local
aaa authorization network scoobee group radius local
aaa accounting network charley start-stop group radius group tacacs+

username root password ALongPassword

tacacs-server host 172.31.255.0
tacacs-server key goaway

radius-server host 172.16.2.7
radius-server key myRaDiUSpassWoRd

interface group-async 1
 group-range 1 16
 encapsulation ppp
 ppp authentication chap dialins
 ppp authorization scoobee
 ppp accounting charley

line 1 16
 autoselect ppp
 autoselect during-login
 login authentication admins
 modem dialin
```

The lines in this sample RADIUS AAA configuration are defined as follows:

- The **aaa new-model** command enables AAA network security services.
- The **aaa authentication login admins local** command defines a method list, “admins”, for login authentication.
- The **aaa authentication ppp dialins group radius local** command defines the authentication method list “dialins”, which specifies that first RADIUS authentication and then (if the RADIUS server does not respond) local authentication will be used on serial lines using PPP.
- The **aaa authorization network scoobee group radius local** command defines the network authorization method list named “scoobee”, which specifies that RADIUS authorization will be used on serial lines using PPP. If the RADIUS server fails to respond, then local network authorization will be performed.
- The **aaa accounting network charley start-stop group radius group tacacs+** command defines the network accounting method list named charley, which specifies that RADIUS accounting services (in this case, start and stop records for specific events) will be used on serial lines using PPP. If the RADIUS server fails to respond, accounting services will be handled by a TACACS+ server.
- The **username** command defines the username and password to be used for the PPP Password Authentication Protocol (PAP) caller identification.
- The **tacacs-server host** command defines the name of the TACACS+ server host.

- The **tacacs-server key** command defines the shared secret text string between the network access server and the TACACS+ server host.
- The **radius-server host** command defines the name of the RADIUS server host.
- The **radius-server key** command defines the shared secret text string between the network access server and the RADIUS server host.
- The **interface group-async** command selects and defines an asynchronous interface group.
- The **group-range** command defines the member asynchronous interfaces in the interface group.
- The **encapsulation ppp** command sets PPP as the encapsulation method used on the specified interfaces.
- The **ppp authentication chap dialins** command selects Challenge Handshake Authentication Protocol (CHAP) as the method of PPP authentication and applies the “dialins” method list to the specified interfaces.
- The **ppp authorization scoobee** command applies the scoobee network authorization method list to the specified interfaces.
- The **ppp accounting charley** command applies the charley network accounting method list to the specified interfaces.
- The **line** command switches the configuration mode from global configuration to line configuration and identifies the specific lines being configured.
- The **autoselect ppp** command configures the Cisco IOS software to allow a PPP session to start up automatically on these selected lines.
- The **autoselect during-login** command is used to display the username and password prompt without pressing the Return key. After the user logs in, the autoselect function (in this case, PPP) begins.
- The **login authentication admins** command applies the admins method list for login authentication.
- The **modem dialin** command configures modems attached to the selected lines to only accept incoming calls.

The **show accounting** command yields the following output for the preceding configuration:

```
Active Accounted actions on tty1, User rubble Priv 1
Task ID 5, Network Accounting record, 00:00:52 Elapsed
task_id=5 service=ppp protocol=ip address=10.0.0.98
```

Table 13 describes the fields contained in the preceding output.

Table 13 *show accounting Field Descriptions*

Field	Description
Active Accounted actions on	Terminal line or interface name user with which the user logged in.
User	User's ID.
Priv	User's privilege level.
Task ID	Unique identifier for each accounting session.
Accounting Record	Type of accounting session.
Elapsed	Length of time (hh:mm:ss) for this session type.
attribute=value	AV pairs associated with this accounting session.

Configuring AAA Resource Accounting

The following example shows how to configure the resource failure stop accounting and resource accounting for start-stop records functions:

```
!Enable AAA on your network access server.
aaa new-model
!Enable authentication at login and list the AOL string name to use for login
authentication.
aaa authentication login AOL group radius local
!Enable authentication for ppp and list the default method to use for PPP authentication.
aaa authentication ppp default group radius local
!Enable authorization for all exec sessions and list the AOL string name to use for
authorization.
aaa authorization exec AOL group radius if-authenticated
!Enable authorization for all network-related service requests and list the default method
to use for all network-related authorizations.
aaa authorization network default group radius if-authenticated
!Enable accounting for all exec sessions and list the default method to use for all
start-stop accounting services.
aaa accounting exec default start-stop group radius
!Enable accounting for all network-related service requests and list the default method to
use for all start-stop accounting services.
aaa accounting network default start-stop group radius
!Enable failure stop accounting.
aaa accounting resource default stop-failure group radius
!Enable resource accounting for start-stop records.
aaa accounting resource default start-stop group radius
```

Configuring AAA Broadcast Accounting Example

The following example shows how to turn on broadcast accounting using the global **aaa accounting** command:

```
aaa group server radius isp
 server 1.0.0.1
 server 1.0.0.2

aaa group server tacacs+ isp_customer
 server 3.0.0.1

aaa accounting network default start-stop broadcast group isp group isp_customer

radius-server host 1.0.0.1
radius-server host 1.0.0.2
radius-server key key1
tacacs-server host 3.0.0.1 key key2
```

The **broadcast** keyword causes “start” and “stop” accounting records for network connections to be sent simultaneously to server 1.0.0.1 in the group isp and to server 3.0.0.1 in the group isp_customer. If server 1.0.0.1 is unavailable, failover to server 1.0.0.2 occurs. If server 3.0.0.1 is unavailable, no failover occurs because backup servers are not configured for the group isp_customer.

Configuring Per-DNIS AAA Broadcast Accounting Example

The following example shows how to turn on per DNIS broadcast accounting using the global **aaa dnis map accounting network** command:

```
aaa group server radius isp
  server 1.0.0.1
  server 1.0.0.2

aaa group server tacacs+ isp_customer
  server 3.0.0.1

aaa dnis map enable
aaa dnis map 7777 accounting network start-stop broadcast group isp group isp_customer

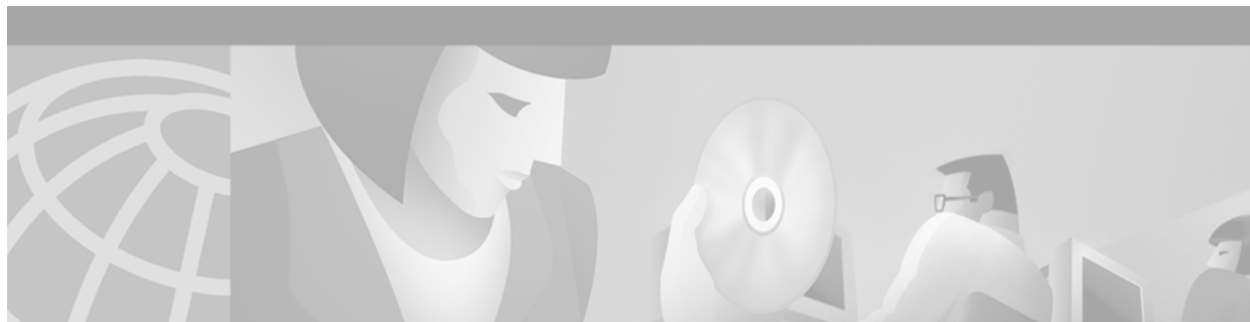
radius-server host 1.0.0.1
radius-server host 1.0.0.2
radius-server key key_1
tacacs-server host 3.0.0.1 key key_2
```

The **broadcast** keyword causes “start” and “stop” accounting records for network connection calls having DNIS number 7777 to be sent simultaneously to server 1.0.0.1 in the group isp and to server 3.0.0.1 in the group isp_customer. If server 1.0.0.1 is unavailable, failover to server 1.0.0.2 occurs. If server 3.0.0.1 is unavailable, no failover occurs because backup servers are not configured for the group isp_customer.

AAA Session MIB Example

The following example shows how to set up the AAA session MIB feature to disconnect authenticated client connections for PPP users:

```
aaa new-model
aaa authentication ppp default group radius
aaa authorization network default group radius
aaa accounting network default start-stop group radius
aaa session-mib disconnect
```



Configuring RADIUS

This chapter describes the Remote Authentication Dial-In User Service (RADIUS) security system, defines its operation, and identifies appropriate and inappropriate network environments for using RADIUS technology. The “[RADIUS Configuration Task List](#)” section describes how to configure RADIUS with the authentication, authorization, and accounting (AAA) command set.

For a complete description of the RADIUS commands used in this chapter, refer to the chapter “RADIUS Commands” in the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the “Identifying Supported Platforms” section in the “Using Cisco IOS Software” chapter.

In This Chapter

This chapter includes the following sections:

- [About RADIUS](#)
- [RADIUS Operation](#)
- [RADIUS Configuration Task List](#)
- [Monitoring and Maintaining RADIUS](#)
- [RADIUS Attributes](#)
- [RADIUS Configuration Examples](#)

About RADIUS

RADIUS is a distributed client/server system that secures networks against unauthorized access. In the Cisco implementation, RADIUS clients run on Cisco routers and send authentication requests to a central RADIUS server that contains all user authentication and network service access information.

RADIUS is a fully open protocol, distributed in source code format, that can be modified to work with any security system currently available on the market.

Cisco supports RADIUS under its AAA security paradigm. RADIUS can be used with other AAA security protocols, such as TACACS+, Kerberos, and local username lookup. RADIUS is supported on all Cisco platforms, but some RADIUS-supported features run only on specified platforms.

RADIUS has been implemented in a variety of network environments that require high levels of security while maintaining network access for remote users.

Use RADIUS in the following network environments that require access security:

- Networks with multiple-vendor access servers, each supporting RADIUS. For example, access servers from several vendors use a single RADIUS server-based security database. In an IP-based network with multiple vendors' access servers, dial-in users are authenticated through a RADIUS server that has been customized to work with the Kerberos security system.
- Turnkey network security environments in which applications support the RADIUS protocol, such as in an access environment that uses a "smart card" access control system. In one case, RADIUS has been used with Enigma's security cards to validate users and grant access to network resources.
- Networks already using RADIUS. You can add a Cisco router with RADIUS to the network. This might be the first step when you make a transition to a Terminal Access Controller Access Control System Plus (TACACS+) server.
- Networks in which a user must only access a single service. Using RADIUS, you can control user access to a single host, to a single utility such as Telnet, or to a single protocol such as Point-to-Point Protocol (PPP). For example, when a user logs in, RADIUS identifies this user as having authorization to run PPP using IP address 10.2.3.4 and the defined access list is started.
- Networks that require resource accounting. You can use RADIUS accounting independent of RADIUS authentication or authorization. The RADIUS accounting functions allow data to be sent at the start and end of services, indicating the amount of resources (such as time, packets, bytes, and so on) used during the session. An Internet service provider (ISP) might use a freeware-based version of RADIUS access control and accounting software to meet special security and billing needs.
- Networks that wish to support preauthentication. Using the RADIUS server in your network, you can configure AAA preauthentication and set up the preauthentication profiles. Preauthentication enables service providers to better manage ports using their existing RADIUS solutions, and to efficiently manage the use of shared resources to offer differing service-level agreements.

RADIUS is not suitable in the following network security situations:

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

RADIUS Operation

When a user attempts to log in and authenticate to an access server using RADIUS, the following steps occur:

1. The user is prompted for and enters a username and password.
2. The username and encrypted password are sent over the network to the RADIUS server.

3. The user receives one of the following responses from the RADIUS server:
 - a. **ACCEPT**—The user is authenticated.
 - b. **REJECT**—The user is not authenticated and is prompted to reenter the username and password, or access is denied.
 - c. **CHALLENGE**—A challenge is issued by the RADIUS server. The challenge collects additional data from the user.
 - d. **CHANGE PASSWORD**—A request is issued by the RADIUS server, asking the user to select a new password.

The **ACCEPT** or **REJECT** response is bundled with additional data that is used for EXEC or network authorization. You must first complete RADIUS authentication before using RADIUS authorization. The additional data included with the **ACCEPT** or **REJECT** packets consists of the following:

- Services that the user can access, including Telnet, rlogin, or local-area transport (LAT) connections, and PPP, Serial Line Internet Protocol (SLIP), or EXEC services.
- Connection parameters, including the host or client IP address, access list, and user timeouts.

RADIUS Configuration Task List

To configure RADIUS on your Cisco router or access server, you must perform the following tasks:

- Use the **aaa new-model** global configuration command to enable AAA. AAA must be configured if you plan to use RADIUS. For more information about using the **aaa new-model** command, refer to the “AAA Overview” chapter.
- Use the **aaa authentication** global configuration command to define method lists for RADIUS authentication. For more information about using the **aaa authentication** command, refer to the “Configuring Authentication” chapter.
- Use **line** and **interface** commands to enable the defined method lists to be used. For more information, refer to the “Configuring Authentication” chapter.

The following configuration tasks are optional:

- You may use the **aaa group server** command to group selected RADIUS hosts for specific services. For more information about using the **aaa group server** command, refer to the [“Configuring AAA Server Groups”](#) section in this chapter.
- You may use the **aaa dnis map** command to select RADIUS server groups based on DNIS number. To use this command, you must define RADIUS server groups using the **aaa group server** command. For more information about using the **aaa dnis map** command, refer to the section [“Configuring AAA Server Group Selection Based on DNIS”](#) in this chapter.
- You may use the **aaa authorization** global command to authorize specific user functions. For more information about using the **aaa authorization** command, refer to the chapter “Configuring Authorization.”
- You may use the **aaa accounting** command to enable accounting for RADIUS connections. For more information about using the **aaa accounting** command, refer to the chapter “Configuring Accounting.”
- You may use the **dialer aaa** interface configuration command to create remote site profiles that contain outgoing call attributes on the AAA server. For more information about using the **dialer aaa** command, refer to the section [“Configuring Suffix and Password in RADIUS Access Requests”](#) in this chapter.

This section describes how to set up RADIUS for authentication, authorization, and accounting on your network, and includes the following sections:

- [Configuring Router to RADIUS Server Communication](#) (Required)
- [Configuring Router to Use Vendor-Specific RADIUS Attributes](#) (Optional)
- [Configuring Router for Vendor-Proprietary RADIUS Server Communication](#) (Optional)
- [Configuring Router to Query RADIUS Server for Static Routes and IP Addresses](#) (Optional)
- [Configuring Router to Expand Network Access Server Port Information](#) (Optional)
- [Configuring AAA Server Groups](#) (Optional)
- [Configuring AAA Server Groups with Deadtme](#) (Optional)
- [Configuring AAA DNIS Authentication](#)
- [Configuring AAA Server Group Selection Based on DNIS](#) (Optional)
- [Configuring AAA Preauthentication](#)
- [Configuring a Guard Timer](#)
- [Specifying RADIUS Authentication](#)
- [Specifying RADIUS Authorization](#) (Optional)
- [Specifying RADIUS Accounting](#) (Optional)
- [Configuring RADIUS Login-IP-Host](#) (Optional)
- [Configuring RADIUS Prompt](#) (Optional)
- [Configuring Suffix and Password in RADIUS Access Requests](#) (Optional)

For RADIUS configuration examples using the commands in this chapter, refer to the section “[RADIUS Configuration Examples](#)” at the end of this chapter.

Configuring Router to RADIUS Server Communication

The RADIUS host is normally a multiuser system running RADIUS server software from Cisco (CiscoSecure ACS), Livingston, Merit, Microsoft, or another software provider. Configuring router to RADIUS server communication can have several components:

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

RADIUS security servers are identified on the basis of their host name or IP address, host name and specific UDP port numbers, or IP address and specific UDP port numbers. The combination of the IP address and UDP port number creates a unique identifier, allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. In other words, this unique identifier enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service—for example, accounting—the second host entry configured acts as fail-over backup to the first one. Using this

example, if the first host entry fails to provide accounting services, the network access server will try the second host entry configured on the same device for accounting services. (The RADIUS host entries will be tried in the order they are configured.)

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

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

**Note**

You can configure both global and per-server timeout, retransmission, and key value commands simultaneously on the same Cisco network access server. If both global and per-server functions are configured on a router, the per-server timer, retransmission, and key value commands override global timer, retransmission, and key value commands.

To configure per-server RADIUS server communication, use the following command in global configuration mode:

Command	Purpose
Router(config)# radius-server host {hostname ip-address} [auth-port port-number] [acct-port port-number] [timeout seconds] [retransmit retries] [key string] [alias {hostname ip address}]	<p>Specifies the IP address or host name of the remote RADIUS server host and assign authentication and accounting destination port numbers. Use the auth-port <i>port-number</i> option to configure a specific UDP port on this RADIUS server to be used solely for authentication. Use the acct-port <i>port-number</i> option to configure a specific UDP port on this RADIUS server to be used solely for accounting. Use the alias keyword to configure up to eight multiple IP addresses for use when referring to RADIUS servers.</p> <p>To configure the network access server to recognize more than one host entry associated with a single IP address, simply repeat this command as many times as necessary, making sure that each UDP port number is different. Set the timeout, retransmit, and encryption key values to use with the specific RADIUS host.</p> <p>If no timeout is set, the global value is used; otherwise, enter a value in the range 1 to 1000. If no retransmit value is set, the global value is used; otherwise enter a value in the range 1 to 1000. If no key string is specified, the global value is used.</p> <p>Note The key is a text string that must match the encryption key used on the RADIUS server. Always configure the key as the last item in the radius-server host command syntax because the leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks themselves are part of the key.</p>

To configure global communication settings between the router and a RADIUS server, use the following **radius-server** commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# radius-server key {0 <i>string</i> 7 <i>string</i> <i>string</i> }	Specifies the shared secret text string used between the router and a RADIUS server. Use the 0 line option to configure an unencrypted shared secret. Use the 7 line option to configure an encrypted shared secret.
Step 2	Router(config)# radius-server retransmit <i>retries</i>	Specifies how many times the router transmits each RADIUS request to the server before giving up (the default is 3).
Step 3	Router(config)# radius-server timeout <i>seconds</i>	Specifies for how many seconds a router waits for a reply to a RADIUS request before retransmitting the request.
Step 4	Router(config)# radius-server deadtime <i>minutes</i>	Specifies for how many minutes a RADIUS server that is not responding to authentication requests is passed over by requests for RADIUS authentication.

Configuring Router to Use Vendor-Specific RADIUS Attributes

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

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

"Protocol" is a value of the Cisco "protocol" attribute for a particular type of authorization; protocols that can be used include IP, IPX, VPDN, VOIP, SHELL, RSVP, SIP, AIRNET, OUTBOUND. "Attribute" and "value" are an appropriate attribute-value (AV) pair defined in the Cisco TACACS+ specification, and "sep" is "=" for mandatory attributes and "*" for optional attributes. This allows the full set of features available for TACACS+ authorization to also be used for RADIUS.

For example, the following AV pair causes Cisco's "multiple named ip address pools" feature to be activated during IP authorization (during PPP's IPCP address assignment):

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

If you insert an "*", the AV pair "ip:addr-pool=first" becomes optional. Note that any AV pair can be made optional.

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

The following example shows how to cause a user logging in from a network access server to have immediate access to EXEC commands:

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


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

To configure the network access server to recognize and use VSAs, use the following command in global configuration mode:

Command	Purpose
Router(config)# radius-server vsa send [accounting authentication]	Enables the network access server to recognize and use VSAs as defined by RADIUS IETF attribute 26.

For a complete list of RADIUS attributes or more information about vendor-specific attribute 26, refer to the appendix “RADIUS Attributes.”

Configuring Router for Vendor-Proprietary RADIUS Server Communication

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

As mentioned earlier, to configure RADIUS (whether vendor-proprietary or IETF draft-compliant), you must specify the host running the RADIUS server daemon and the secret text string it shares with the Cisco device. You specify the RADIUS host and secret text string by using the **radius-server** commands. To identify that the RADIUS server is using a vendor-proprietary implementation of RADIUS, use the **radius-server host non-standard** command. Vendor-proprietary attributes will not be supported unless you use the **radius-server host non-standard** command.

To specify a vendor-proprietary RADIUS server host and a shared secret text string, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# radius-server host { <i>hostname</i> <i>ip-address</i> } non-standard	Specifies the IP address or host name of the remote RADIUS server host and identifies that it is using a vendor-proprietary implementation of RADIUS.
Step 2	Router(config)# radius-server key { <i>0 string</i> <i>7 string</i> <i>string</i> }	Specifies the shared secret text string used between the router and the vendor-proprietary RADIUS server. The router and the RADIUS server use this text string to encrypt passwords and exchange responses.

Configuring Router to Query RADIUS Server for Static Routes and IP Addresses

Some vendor-proprietary implementations of RADIUS let the user define static routes and IP pool definitions on the RADIUS server instead of on each individual network access server in the network. Each network access server then queries the RADIUS server for static route and IP pool information.

To have the Cisco router or access server query the RADIUS server for static routes and IP pool definitions when the device first starts up, use the following command in global configuration mode:

Command	Purpose
Router(config)# radius-server configure-nas	Tells the Cisco router or access server to query the RADIUS server for the static routes and IP pool definitions used throughout its domain.



Note

Because the **radius-server configure-nas** command is performed when the Cisco router starts up, it will not take effect until you issue a **copy system:running config nvram:startup-config** command.

Configuring Router to Expand Network Access Server Port Information

There are some situations when PPP or login authentication occurs on an interface different from the interface on which the call itself comes in. For example, in a V.120 ISDN call, login or PPP authentication occurs on a virtual asynchronous interface “ttr” but the call itself occurs on one of the channels of the ISDN interface.

The **radius-server attribute nas-port extended** command configures RADIUS to expand the size of the NAS-Port attribute (RADIUS IETF attribute 5) field to 32 bits. The upper 16 bits of the NAS-Port attribute display the type and number of the controlling interface; the lower 16 bits indicate the interface undergoing authentication.

To display expanded interface information in the NAS-Port attribute field, use the following command in global configuration mode:

Command	Purpose
Router(config)# radius-server attribute nas-port format	Expands the size of the NAS-Port attribute from 16 to 32 bits to display extended interface information.



Note

This command replaces the **radius-server extended-portnames** command and the **radius-server attribute nas-port extended** command.

On platforms with multiple interfaces (ports) per slot, the Cisco RADIUS implementation will not provide a unique NAS-Port attribute that permits distinguishing between the interfaces. For example, if a dual PRI interface is in slot 1, calls on both Serial1/0:1 and Serial1/1:1 will appear as NAS-Port = 20101.

Once again, this is because of the 16-bit field size limitation associated with RADIUS IETF NAS-Port attribute. In this case, the solution is to replace the NAS-Port attribute with a vendor-specific attribute (RADIUS IETF attribute 26). Cisco's vendor-ID is 9, and the Cisco-NAS-Port attribute is subtype 2.

Vendor-specific attributes (VSAs) can be turned on by entering the **radius-server vsa send** command. The port information in this attribute is provided and configured using the **aaa nas port extended** command.

To replace the NAS-Port attribute with RADIUS IETF attribute 26 and to display extended field information, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# radius-server vsa send [accounting authentication]	Enables the network access server to recognize and use vendor-specific attributes as defined by RADIUS IETF attribute 26.
Step 2	Router(config)# aaa nas port extended	Expands the size of the VSA NAS-Port field from 16 to 32 bits to display extended interface information.

The standard NAS-Port attribute (RADIUS IETF attribute 5) will continue to be sent. If you do not want this information to be sent, you can suppress it by using the **no radius-server attribute nas-port** command. When this command is configured, the standard NAS-Port attribute will no longer be sent.

For a complete list of RADIUS attributes, refer to the appendix “RADIUS Attributes.”

For information about configuring RADIUS port identification for PPP, see the *Cisco IOS Wide-Area Networking Configuration Guide*.

Configuring AAA Server Groups

Configuring the router to use AAA server groups provides a way to group existing server hosts. This allows you to select a subset of the configured server hosts and use them for a particular service. A server group is used in conjunction with a global server-host list. The server group lists the IP addresses of the selected server hosts.

Server groups also can include multiple host entries for the same server, as long as each entry has a unique identifier. The combination of an IP address and a UDP port number creates a unique identifier, allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. In other words, this unique identifier enables RADIUS requests to be sent to different UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service—for example, accounting—the second host entry configured acts as failover backup to the first one. Using this example, if the first host entry fails to provide accounting services, the network access server will try the second host entry configured on the same device for accounting services. (The RADIUS host entries will be tried in the order in which they are configured.)

To define a server host with a server group name, enter the following commands in global configuration mode. The listed server must exist in global configuration mode:

	Command	Purpose
Step 1	Router(config)# radius-server host {hostname ip-address} [auth-port port-number] [acct-port port-number] [timeout seconds] [retransmit retries] [key string] [alias {hostname ip address}]	Specifies and defines the IP address of the server host before configuring the AAA server-group. Refer to the section “ Configuring Router to RADIUS Server Communication ” of this chapter for more information on the radius-server host command.
Step 2	Router(config-if)# aaa group server {radius tacacs+} group-name	Defines the AAA server group with a group name. All members of a group must be the same type; that is, RADIUS or TACACS+. This command puts the router in server group subconfiguration mode.
Step 3	Router(config-sg)# server ip-address [auth-port port-number] [acct-port port-number]	Associates a particular RADIUS server with the defined server group. Each security server is identified by its IP address and UDP port number. Repeat this step for each RADIUS server in the AAA server group. Note Each server in the group must be defined previously using the radius-server host command.

Configuring AAA Server Groups with Deadtime

After you have configured a server host with a server name, you can use the **deadtime** command to configure each server per server group. Configuring deadtime within a server group allows you to direct AAA traffic to separate groups of servers that have different operational characteristics.

Configuring deadtime is no longer limited to a global configuration. A separate timer has been attached to each server host in every server group. Therefore, when a server is found to be unresponsive after numerous retransmissions and timeouts, the server is assumed to be dead. The timers attached to each server host in all server groups are triggered. In essence, the timers are checked and subsequent requests to a server (once it is assumed to be dead) are directed to alternate timers, if configured. When the network access server receives a reply from the server, it checks and stops all configured timers (if running) for that server in all server groups.

If the timer has expired, only the server to which the timer is attached is assumed to be alive. This becomes the only server that can be tried for later AAA requests using the server groups to which the timer belongs.



Note

Since one server has different timers and may have different deadtime values configured in the server groups, the same server may in the future have different states (dead and alive) at the same time.



Note

To change the state of a server, you must start and stop all configured timers in all server groups.

The size of the server group will be slightly increased because of the addition of new timers and the deadtime attribute. The overall impact of the structure depends on the number and size of the server groups and how the servers are shared among server groups in a specific configuration.

To configure deadtime within a server group, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa group server radius <i>group1</i>	Defines a RADIUS type server group.
Step 2	Router(config-sg)# deadtime <i>1</i>	Configures and defines deadtime value in minutes. Note Local server group deadtime will override the global configuration. If omitted from the local server group configuration, the value will be inherited from the master list.
Step 3	Router(config-sg)# exit	Exits server group configuration mode.

Configuring AAA DNIS Authentication

DNIS preauthentication enables preauthentication at call setup based on the number dialed. The DNIS number is sent directly to the security server when a call is received. If authenticated by AAA, the call is accepted.

To configure DNIS authentication, perform the following tasks in global configuration mode:

	Command	Purpose
Step 1	Router# config term	Enters global configuration mode.
Step 2	Router(config)# aaa preauth	Enters AAA preauthentication mode.
Step 3	Router(config-preauth)# group { radius tacacs+ <i>server-group</i> }	(Optional) Selects the security server to use for AAA preauthentication requests. The default is RADIUS.
Step 4	Router(config-preauth)# dnis [password <i>string</i>]	Enables preauthentication using DNIS and optionally specifies a password to use in Access-Request packets.

Configuring AAA Server Group Selection Based on DNIS

Cisco IOS software allows you to assign a Dialed Number Identification Service (DNIS) number to a particular AAA server group so that the server group can process authentication, authorization, and accounting requests for users dialing in to the network using that particular DNIS. Any phone line (a regular home phone or a commercial T1/PRI line) can be associated with several phone numbers. The DNIS number identifies the number that was called to reach you.

For example, suppose you want to share the same phone number with several customers, but you want to know which customer is calling before you pick up the phone. You can customize how you answer the phone because DNIS allows you to know which customer is calling when you answer.

Cisco routers with either ISDN or internal modems can receive the DNIS number. This functionality allows users to assign different RADIUS server groups for different customers (that is, different RADIUS servers for different DNIS numbers). Additionally, using server groups you can specify the same server group for AAA services or a separate server group for each AAA service.

Cisco IOS software provides the flexibility to implement authentication and accounting services in several ways:

- Globally—AAA services are defined using global configuration access list commands and applied in general to all interfaces on a specific network access server.
- Per Interface—AAA services are defined using interface configuration commands and applied specifically to the interface being configured on a specific network access server.
- DNIS mapping—You can use DNIS to specify an AAA server to supply AAA services.

Because each of these AAA configuration methods can be configured simultaneously, Cisco has established an order of precedence to determine which server or groups of servers provide AAA services. The order of precedence is as follows:

- Per DNIS—If you configure the network access server to use DNIS to identify/determine which server group provides AAA services, then this method takes precedence over any additional AAA selection method.
- Per interface—If you configure the network access server per interface to use access lists to determine how a server provides AAA services, this method takes precedence over any global configuration AAA access lists.
- Globally—If you configure the network access server by using global AAA access lists to determine how the security server provides AAA services, this method has the least precedence.



Note

Prior to configuring AAA Server Group Selection Based on DNIS, you must configure the list of RADIUS server hosts and configure the AAA server groups. See the sections [“Configuring Router to RADIUS Server Communication”](#) and [“Configuring AAA Server Groups”](#) of this chapter.

To configure the router to select a particular AAA server group based on the DNIS of the server group, configure DNIS mapping. To map a server group with a group name with DNIS number, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa dnis map enable	Enables DNIS mapping.
Step 2	Router(config)# aaa dnis map dnis-number authentication ppp group server-group-name	Maps a DNIS number to a defined AAA server group; the servers in this server group are being used for authentication.
Step 3	Router(config)# aaa dnis map dnis-number authorization network group server-group-name	Maps a DNIS number to a defined AAA server group; the servers in this server group are being used for authorization.
Step 4	Router(config)# aaa dnis map dnis-number accounting network [none start-stop stop-only] group server-group-name	Maps a DNIS number to a defined AAA server group; the servers in this server group are being used for accounting.

Configuring AAA Preauthentication

Configuring AAA preauthentication with ISDN PRI or channel-associated signalling (CAS) allows service providers to better manage ports using their existing RADIUS solutions and efficiently manage the use of shared resources to offer differing service-level agreements. With ISDN PRI or CAS, information about an incoming call is available to the network access server (NAS) before the call is connected. The available call information includes the following:

- The Dialed Number Identification Service (DNIS) number, also referred to as the called number
- The Calling Line Identification (CLID) number, also referred to as the calling number
- The call type, also referred to as the bearer capability

This feature allows a Cisco NAS to decide—on the basis of the DNIS number, the CLID number, or the call type—whether to connect an incoming call. (With ISDN PRI, it enables user authentication and authorization before a call is answered. With CAS, the call must be answered; however, the call can be dropped if preauthentication fails.)

When an incoming call arrives from the public network switch, but before it is connected, AAA preauthentication enables the NAS to send the DNIS number, CLID number, and call type to a RADIUS server for authorization. If the server authorizes the call, then the NAS accepts the call. If the server does not authorize the call, then the NAS sends a disconnect message to the public network switch to reject the call.

In the event that the RADIUS server application becomes unavailable or is slow to respond, a guard timer can be set in the NAS. When the timer expires, the NAS uses a configurable parameter to accept or reject the incoming call that has no authorization.

This feature supports the use of attribute 44 by the RADIUS server application and the use of RADIUS attributes that are configured in the RADIUS preauthentication profiles to specify preauthentication behavior. They may also be used, for instance, to specify whether subsequent authentication should occur and, if so, what authentication method should be used.

The following restrictions apply to AAA preauthentication with ISDN PRI and CAS:

- Attribute 44 is available for CAS calls only when preauthentication or resource pooling is enabled.
- MMP is not available with ISDN PRI.
- AAA preauthentication is available only on the Cisco AS5300, Cisco AS5400, and Cisco AS5800 platforms.

**Note**

Prior to configuring AAA preauthentication, you must enable the **aaa new-model** command and make sure the supporting preauthentication application is running on a RADIUS server in your network.

To configure AAA preauthentication, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa preauth	Enters AAA preauthentication configuration mode.
Step 2	Router(config-preauth)# group <i>server-group</i>	Specifies the AAA RADIUS server group to use for preauthentication.

	Command	Purpose
Step 3	Router(config-preauth)# clid [if-avail required] [accept-stop] [password <i>string</i>]	Preauthenticates calls on the basis of the CLID number.
Step 4	Router(config-preauth)# ctype [if-avail required] [accept-stop] [password <i>string</i>]	Preauthenticates calls on the basis of the call type.
Step 5	Router(config-preauth)# dnis [if-avail required] [accept-stop] [password <i>string</i>]	Preauthenticates calls on the basis of the DNIS number.
Step 6	Router(config-preauth)# dnis bypass { <i>dnis-group-name</i> }	Specifies a group of DNIS numbers that will be bypassed for preauthentication.

To configure DNIS preauthentication, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa preauth	Enters AAA preauthentication mode.
Step 2	Router(config-preauth)# group { radius tacacs+ <i>server-group</i> }	(Optional) Selects the security server to use for AAA preauthentication requests. The default is RADIUS.
Step 3	Router(config-preauth)# dnis [password <i>string</i>]	Enables preauthentication using DNIS and optionally specifies a password to use in Access-Request packets.

In addition to configuring preauthentication on your Cisco router, you must set up the preauthentication profiles on the RADIUS server. For information on setting up the preauthentication profiles, see the following sections:

- [Setting Up the RADIUS Profile for DNIS or CLID Preauthentication](#)
- [Setting Up the RADIUS Profile for Call Type Preauthentication](#)
- [Setting Up the RADIUS Profile for Preauthentication Enhancements for Callback](#)
- [Setting Up the RADIUS Profile for a Remote Host Name Used for Large-Scale Dial-Out](#)
- [Setting Up the RADIUS Profile for Modem Management](#)
- [Setting Up the RADIUS Profile for Subsequent Authentication](#)
- [Setting Up the RADIUS Profile for Subsequent Authentication Type](#)
- [Setting Up the RADIUS Profile to Include the Username](#)
- [Setting Up the RADIUS Profile for Two-Way Authentication](#)
- [Setting Up the RADIUS Profile to Support Authorization](#)

Setting Up the RADIUS Profile for DNIS or CLID Preauthentication

To set up the RADIUS preauthentication profile, use the DNIS or CLID number as the username, and use the password defined in the **dnis** or **clid** command as the password.

**Note**

The preauthentication profile must have “outbound” as the service type because the password is predefined on the NAS. Setting up the preauthentication profile in this manner prevents users from trying to log in to the NAS with the username of the DNIS number, CLID number, or call type and an obvious password. The “outbound” service type is also included in the access-request packet sent to the RADIUS server.

Setting Up the RADIUS Profile for Call Type Preauthentication

To set up the RADIUS preauthentication profile, use the call type string as the username, and use the password defined in the **ctype** command as the password. The following table shows the call type strings that may be used in the preauthentication profile:

Call Type String	ISDN Bearer Capabilities
digital	Unrestricted digital, restricted digital.
speech	Speech, 3.1 kHz audio, 7 kHz audio. Note This is the only call type available for CAS.
v.110	Anything with V.110 user information layer.
v.120	Anything with V.120 user information layer.

**Note**

The preauthentication profile must have “outbound” as the service type because the password is predefined on the NAS. Setting up the preauthentication profile in this manner prevents users from trying to log in to the NAS with the username of the DNIS number, CLID number, or call type and an obvious password. The “outbound” service type is also included in the access-request packet sent to the RADIUS server and should be a check-in item if the RADIUS server supports check-in items.

Setting Up the RADIUS Profile for Preauthentication Enhancements for Callback

Callback allows remote network users such as telecommuters to dial in to the NAS without being charged. When callback is required, the NAS hangs up the current call and dials the caller back. When the NAS performs the callback, only information for the outgoing connection is applied. The rest of the attributes from the preauthentication access-accept message are discarded.

**Note**

The destination IP address is not required to be returned from the RADIUS server.

The following example shows a RADIUS profile configuration with a callback number of 555-1111 and the service type set to outbound. The `cisco-avpair = “preauth:send-name=<string>”` uses the string “andy” and the `cisco-avpair = “preauth:send-secret=<string>”` uses the password “cisco.”

```
5551111 password = "cisco", Service-Type = Outbound
    Service-Type = Callback-Framed
    Framed-Protocol = PPP,
    Dialback-No = "5551212"
    Class = "ISP12"
    cisco-avpair = "preauth:send-name=andy"
    cisco-avpair = "preauth:send-secret=cisco"
```

Setting Up the RADIUS Profile for a Remote Host Name Used for Large-Scale Dial-Out

The following example adds to the previous example by protecting against accidentally calling a valid telephone number but accessing the wrong router by providing the name of the remote, for use in large-scale dial-out:

```
5551111 password = "cisco", Service-Type = Outbound
    Service-Type = Callback-Framed
    Framed-Protocol = PPP,
    Dialback-No = "5551212"
    Class = "ISP12"
    cisco-avpair = "preauth:send-name=andy"
    cisco-avpair = "preauth:send-secret=cisco"
    cisco-avpair = "preauth:remote-name=Router2"
```

Setting Up the RADIUS Profile for Modem Management

When DNIS, CLID, or call type preauthentication is used, the affirmative response from the RADIUS server may include a modem string for modem management in the NAS through vendor-specific attribute (VSA) 26. The modem management VSA has the following syntax:

```
cisco-avpair = "preauth:modem-service=modem min-speed <x> max-speed <y>
modulation <z> error-correction <a> compression <b>"
```

The modem management string within the VSA may contain the following:

Command	Argument
min-speed	<300 to 56000>, any
max-speed	<300 to 56000>, any
modulation	K56Flex, v22bis, v32bis, v34, v90, any
error-correction	lapm, mnp4
compression	mnp5, v42bis

When the modem management string is received from the RADIUS server in the form of a VSA, the information is passed to the Cisco IOS software and applied on a per-call basis. Modem ISDN channel aggregation (MICA) modems provide a control channel through which messages can be sent during the call setup time. Hence, this modem management feature is supported only with MICA modems and newer technologies. This feature is not supported with Microcom modems.

For more information on modem management, refer to the “Modem Configuration and Management” chapter of the *Cisco IOS Dial Technologies Configuration Guide*, Release 12.2.

Setting Up the RADIUS Profile for Subsequent Authentication

If preauthentication passes, you may use vendor-proprietary RADIUS attribute 201 (Require-Auth) in the preauthentication profile to determine whether subsequent authentication is to be performed. If attribute 201, returned in the access-accept message, has a value of 0, then subsequent authentication will not be performed. If attribute 201 has a value of 1, then subsequent authentication will be performed as usual.

Attribute 201 has the following syntax:

```
cisco-avpair = "preauth:auth-required=<n>"
```

where <n> has the same value range as attribute 201 (that is, 0 or 1).

If attribute 201 is missing in the preauthentication profile, then a value of 1 is assumed, and subsequent authentication is performed.

**Note**

To perform subsequent authentication, you must set up a regular user profile in addition to a preauthentication profile.

Setting Up the RADIUS Profile for Subsequent Authentication Type

If you have specified subsequent authentication in the preauthentication profile, you must also specify the authentication types to be used for subsequent authentication. To specify the authentication types allowed in subsequent authentication, use the following VSA:

```
cisco-avpair = "preauth:auth-type=<string>"
```

where <string> can be one of the following:

String	Description
chap	Requires username and password of CHAP for PPP authentication.
ms-chap	Requires username and password of MS-CHAP for PPP authentication.
pap	Requires username and password of PAP for PPP authentication.

To specify that multiple authentication types are allowed, you can configure more than one instance of this VSA in the preauthentication profile. The sequence of the authentication type VSAs in the preauthentication profile is significant because it specifies the order of authentication types to be used in the PPP negotiation.

This VSA is a per-user attribute and replaces the authentication type list in the **ppp authentication** interface command.

**Note**

You should use this VSA only if subsequent authentication is required because it specifies the authentication type for subsequent authentication.

Setting Up the RADIUS Profile to Include the Username

If only preauthentication is used to authenticate a call, the NAS could be missing a username when it brings up the call. RADIUS may provide a username for the NAS to use through RADIUS attribute 1 (User-Name) or through a VSA returned in the access-accept packet. The VSA for specifying the username has the following syntax:

```
cisco-avpair = "preauth:username=<string>"
```

If no username is specified, the DNIS number, CLID number, or call type is used, depending on the last preauthentication command that has been configured (for example, if **clid** was the last preauthentication command configured, the CLID number will be used as the username).

If subsequent authentication is used to authenticate a call, there might be two usernames: one provided by RADIUS and one provided by the user. In this case, the username provided by the user overrides the one contained in the RADIUS preauthentication profile; the username provided by the user is used for both authentication and accounting.

Setting Up the RADIUS Profile for Two-Way Authentication

In the case of two-way authentication, the calling networking device will need to authenticate the NAS. The Password Authentication Protocol (PAP) username and password or Challenge Handshake Authentication Protocol (CHAP) username and password need not be configured locally on the NAS. Instead, username and password can be included in the access-accept messages for preauthentication.



Note

The **ppp authentication** command must be configured with the **radius** method.

To apply for PAP, do not configure the **ppp pap sent-name password** command on the interface. The vendor-specific attributes (VSAs) “preauth:send-name” and “preauth:send-secret” will be used as the PAP username and PAP password for outbound authentication.

For CHAP, “preauth:send-name” will be used not only for outbound authentication, but also for inbound authentication. For a CHAP inbound case, the NAS will use the name defined in “preauth:send-name” in the challenge packet to the caller networking device. For a CHAP outbound case, both “preauth:send-name” and “preauth:send-secret” will be used in the response packet.

The following example shows a configuration that specifies two-way authentication:

```
5551111 password = "cisco", Service-Type = Outbound
Service-Type = Framed-User
cisco-avpair = "preauth:auth-required=1"
cisco-avpair = "preauth:auth-type=pap"
cisco-avpair = "preauth:send-name=andy"
cisco-avpair = "preauth:send-secret=cisco"
class = "<some class>"
```



Note

Two-way authentication does not work when resource pooling is enabled.

Setting Up the RADIUS Profile to Support Authorization

If only preauthentication is configured, then subsequent authentication will be bypassed. Note that because the username and password are not available, authorization will also be bypassed. However, you may include authorization attributes in the preauthentication profile to apply per-user attributes and avoid having to return subsequently to RADIUS for authorization. To initiate the authorization process, you must also configure the **aaa authorization network** command on the NAS.

You may configure authorization attributes in the preauthentication profile with one exception: the service-type attribute (attribute 6). The service-type attribute must be converted to a VSA in the preauthentication profile. This VSA has the following syntax:

```
cisco-avpair = "preauth:service-type=<n>"
```

where <n> is one of the standard RFC 2138 values for attribute 6. For a list of possible Service-Type values, refer to the appendix RADIUS Attributes.

**Note**

If subsequent authentication is required, the authorization attributes in the preauthentication profile will not be applied.

Configuring a Guard Timer

Because response times for preauthentication and authentication requests can vary, the guard timer allows you to control the handling of calls. The guard timer starts when the DNIS is sent to the RADIUS server. If the NAS does not receive a response from AAA before the guard timer expires, it accepts or rejects the calls on the basis of the configuration of the timer.

To set a guard timer to accept or reject a call in the event that the RADIUS server fails to respond to an authentication or preauthentication request, use one of the following commands in interface configuration mode:

Command	Purpose
<code>Router(config-if)# isdn guard-timer <i>milliseconds</i> [on-expiry {accept reject}]</code>	Sets an ISDN guard timer to accept or reject a call in the event that the RADIUS server fails to respond to a preauthentication request.
<code>Router(control-config)# call guard-timer <i>milliseconds</i> [on-expiry {accept reject}]</code>	Sets a CAS guard timer to accept or reject a call in the event that the RADIUS server fails to respond to a preauthentication request.

Specifying RADIUS Authentication

After you have identified the RADIUS server and defined the RADIUS authentication key, you must define method lists for RADIUS authentication. Because RADIUS authentication is facilitated through AAA, you must enter the **aaa authentication** command, specifying RADIUS as the authentication method. For more information, refer to the chapter “Configuring Authentication.”

Specifying RADIUS Authorization

AAA authorization lets you set parameters that restrict a user’s access to the network. Authorization using RADIUS provides one 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, IPX, ARA, and Telnet. Because RADIUS authorization is facilitated through AAA, you must issue the **aaa authorization** command, specifying RADIUS as the authorization method. For more information, refer to the chapter “Configuring Authorization.”

Specifying RADIUS Accounting

The AAA accounting feature enables you to track the services users are accessing as well as the amount of network resources they are consuming. Because RADIUS accounting is facilitated through AAA, you must issue the **aaa accounting** command, specifying RADIUS as the accounting method. For more information, refer to the chapter “Configuring Accounting.”

Configuring RADIUS Login-IP-Host

To enable the network access server to attempt more than one login host when trying to connect a dial in user, you can enter as many as three Login-IP-Host entries in the user's profile on the RADIUS server. The following example shows that three Login-IP-Host instances have been configured for the user *joeuser*, and that TCP-Clear will be used for the connection:

```
joeuser      Password = xyz
             Service-Type = Login,
             Login-Service = TCP-Clear,
             Login-IP-Host = 10.0.0.0,
             Login-IP-Host = 10.2.2.2,
             Login-IP-Host = 10.255.255.255,
             Login-TCP-Port = 23
```

The order in which the hosts are entered is the order in which they are attempted. Use the **ip tcp synwait-time** command to set the number of seconds that the network access server waits before trying to connect to the next host on the list; the default is 30 seconds.

Your RADIUS server might permit more than three Login-IP-Host entries; however, the network access server supports only three hosts in access-accept packets.

Configuring RADIUS Prompt

To control whether user responses to access-challenge packets are echoed to the screen, you can configure the Prompt attribute in the user profile on the RADIUS server. This attribute is included only in access-challenge packets. The following example shows the Prompt attribute set to No-Echo, which prevents the user's responses from echoing:

```
joeuser Password = xyz
Service-Type = Login,
Login-Service = Telnet,
Prompt = No-Echo,
Login-IP-Host = 172.31.255.255
```

To allow user responses to echo, set the attribute to Echo. If the Prompt attribute is not included in the user profile, responses are echoed by default.

This attribute overrides the behavior of the **radius-server challenge-noecho** command configured on the access server. For example, if the access server is configured to suppress echoing, but the individual user profile allows echoing, then the user responses are echoed.

**Note**

To use the Prompt attribute, your RADIUS server must be configured to support access-challenge packets.

Configuring Suffix and Password in RADIUS Access Requests

Large-scale dial-out eliminates the need to configure dialer maps on every NAS for every destination. Instead, you can create remote site profiles that contain outgoing call attributes on the AAA server. The profile is downloaded by the NAS when packet traffic requires a call to be placed to a remote site.

You can configure the username in the access-request message to RADIUS. The default suffix of the username, “-out,” is appended to the username. The format for composing the username attribute is IP address plus configured suffix.

To provide username configuration capability for large-scale dial-out, the **dialer aaa** command is implemented with the new **suffix** and **password** keywords.

	Command	Purpose
Step 1	Router(config)# aaa new-model	Enables the AAA access control model.
Step 2	Router(config)# aaa route download min	Enables the download static route feature and sets the amount of time between downloads.
Step 3	Router(config)# aaa authorization configuration default	Downloads static route configuration information from the AAA server using TACACS+ or RADIUS.
Step 4	Router(config)# interface dialer 1	Defines a dialer rotary group.
Step 5	Router(config-if)# dialer aaa	Allows a dialer to access the AAA server for dialing information.
Step 6	Router(config-if)# dialer aaa suffix suffix password password	Allows a dialer to access the AAA server for dialing information and specifies a suffix and nondefault password for authentication.

Monitoring and Maintaining RADIUS

To monitor and maintain RADIUS, use the following commands in privileged EXEC mode:

Command	Purpose
Router# debug radius	Displays information associated with RADIUS.
Router# show radius statistics	Displays the RADIUS statistics for accounting and authentication packets.

RADIUS Attributes

The network access server monitors the RADIUS authorization and accounting functions defined by RADIUS attributes in each user-profile. For a list of supported RADIUS attributes, refer to the appendix “RADIUS Attributes.”

This section includes the following sections:

- [Vendor-Proprietary RADIUS Attributes](#)
- [RADIUS Tunnel Attributes](#)

Vendor-Proprietary RADIUS Attributes

An Internet Engineering Task Force (IETF) draft standard for RADIUS specifies a method for communicating vendor-proprietary information between the network access server and the RADIUS server. Some vendors, nevertheless, have extended the RADIUS attribute set in a unique way. Cisco IOS software supports a subset of vendor-proprietary RADIUS attributes. For a list of supported vendor-proprietary RADIUS attributes, refer to the appendix “RADIUS Attributes.”

RADIUS Tunnel Attributes

RADIUS is a security server authentication, authorization, and accounting (AAA) protocol originally developed by Livingston, Inc. RADIUS uses attribute value (AV) pairs to communicate information between the security server and the network access server. RFC 2138 and RFC 2139 describe the basic functionality of RADIUS and the original set of Internet Engineering Task Force (IETF)-standard AV pairs used to send AAA information. Two draft IETF standards, “RADIUS Attributes for Tunnel Protocol Support” and “RADIUS Accounting Modifications for Tunnel Protocol Support,” extend the IETF-defined set of AV pairs to include attributes specific to virtual private networks (VPNs); these attributes are used to carry the tunneling information between the RADIUS server and the tunnel initiator. RFC 2865 and RFC 2868 extend the IETF-defined set of AV pairs to include attributes specific to compulsory tunneling in VPNs by allowing the user to specify authentication names for the network access server and the RADIUS server.

Cisco routers and access servers now support new RADIUS IETF-standard VPDN tunnel attributes. These new RADIUS IETF-standard attributes are listed in the “RADIUS Attributes” appendix. Refer to the following three configuration examples later in this chapter:

- [RADIUS User Profile with RADIUS Tunneling Attributes Example](#)
- [L2TP Access Concentrator Examples](#)
- [L2TP Network Server Examples](#)

For more information about L2F, L2TP, VPN, or VPDN, refer to the *Cisco IOS Dial Technologies Configuration Guide*, Release 12.2.

RADIUS Configuration Examples

The following sections provide RADIUS configuration examples:

- [RADIUS Authentication and Authorization Example](#)
- [RADIUS Authentication, Authorization, and Accounting Example](#)
- [Vendor-Proprietary RADIUS Configuration Example](#)
- [RADIUS Server with Server-Specific Values Example](#)
- [Multiple RADIUS Servers with Global and Server-Specific Values Example](#)
- [Multiple RADIUS Server Entries for the Same Server IP Address Example](#)
- [RADIUS Server Group Examples](#)
- [Multiple RADIUS Server Entries Using AAA Server Groups Example](#)
- [AAA Server Group Selection Based on DNIS Example](#)
- [AAA Preauthentication Examples](#)

- [RADIUS User Profile with RADIUS Tunneling Attributes Example](#)
- [Guard Timer Examples](#)
- [L2TP Access Concentrator Examples](#)
- [L2TP Network Server Examples](#)

RADIUS Authentication and Authorization Example

The following example shows how to configure the router to authenticate and authorize using RADIUS:

```
aaa authentication login use-radius group radius local
aaa authentication ppp user-radius if-needed group radius
aaa authorization exec default group radius
aaa authorization network default group radius
```

The lines in this sample RADIUS authentication and authorization configuration are defined as follows:

- The **aaa authentication login use-radius group radius local** command configures the router to use RADIUS for authentication at the login prompt. If RADIUS returns an error, the user is authenticated using the local database. In this example, **use-radius** is the name of the method list, which specifies RADIUS and then local authentication.
- The **aaa authentication ppp user-radius if-needed group radius** command configures the Cisco IOS software to use RADIUS authentication for lines using PPP with CHAP or PAP if the user has not already been authorized. If the EXEC facility has authenticated the user, RADIUS authentication is not performed. In this example, **user-radius** is the name of the method list defining RADIUS as the if-needed authentication method.
- The **aaa authorization exec default group radius** command sets the RADIUS information that is used for EXEC authorization, autocommands, and access lists.
- The **aaa authorization network default group radius** command sets RADIUS for network authorization, address assignment, and access lists.

RADIUS Authentication, Authorization, and Accounting Example

The following example shows a general configuration using RADIUS with the AAA command set:

```
radius-server host 123.45.1.2
radius-server key myRaDiUSpassWoRd
username root password ALongPassword
aaa authentication ppp dialins group radius local
aaa authorization network default group radius local
aaa accounting network default start-stop group radius
aaa authentication login admins local
aaa authorization exec default local
line 1 16
  autoselect ppp
  autoselect during-login
  login authentication admins
  modem ri-is-cd
interface group-async 1
  encaps ppp
  ppp authentication pap dialins
```

The lines in this example RADIUS authentication, authorization, and accounting configuration are defined as follows:

- The **radius-server host** command defines the IP address of the RADIUS server host.
- The **radius-server key** command defines the shared secret text string between the network access server and the RADIUS server host.
- The **aaa authentication ppp dialins group radius local** command defines the authentication method list “dialins,” which specifies that RADIUS authentication and then (if the RADIUS server does not respond) local authentication will be used on serial lines using PPP.
- The **ppp authentication pap dialins** command applies the “dialins” method list to the lines specified.
- The **aaa authorization network default group radius local** command is used to assign an address and other network parameters to the RADIUS user.
- The **aaa accounting network default start-stop group radius** command tracks PPP usage.
- The **aaa authentication login admins local** command defines another method list, “admins,” for login authentication.
- The **login authentication admins** command applies the “admins” method list for login authentication.

Vendor-Proprietary RADIUS Configuration Example

The following example shows a general configuration using vendor-proprietary RADIUS with the AAA command set:

```
radius-server host alcatraz non-standard
radius-server key myRaDiUSpassWoRd
radius-server configure-nas
username root password ALongPassword
aaa authentication ppp dialins group radius local
aaa authorization network default group radius local
aaa accounting network default start-stop group radius
aaa authentication login admins local
aaa authorization exec default local
line 1 16
autoselect ppp
autoselect during-login
login authentication admins
modem ri-is-cd
interface group-async 1
encaps ppp
ppp authentication pap dialins
```

The lines in this example RADIUS authentication, authorization, and accounting configuration are defined as follows:

- The **radius-server host non-standard** command defines the name of the RADIUS server host and identifies that this RADIUS host uses a vendor-proprietary version of RADIUS.
- The **radius-server key** command defines the shared secret text string between the network access server and the RADIUS server host.
- The **radius-server configure-nas** command defines that the Cisco router or access server will query the RADIUS server for static routes and IP pool definitions when the device first starts up.

- The **aaa authentication ppp dialins group radius local** command defines the authentication method list “dialins,” which specifies that RADIUS authentication, and then (if the RADIUS server does not respond) local authentication will be used on serial lines using PPP.
- The **ppp authentication pap dialins** command applies the “dialins” method list to the lines specified.
- The **aaa authorization network default group radius local** command is used to assign an address and other network parameters to the RADIUS user.
- The **aaa accounting network default start-stop group radius** command tracks PPP usage.
- The **aaa authentication login admins local** command defines another method list, “admins,” for login authentication.
- The **login authentication admins** command applies the “admins” method list for login authentication.

RADIUS Server with Server-Specific Values Example

The following example shows how to configure server-specific timeout, retransmit, and key values for the RADIUS server with IP address 172.31.39.46:

```
radius-server host 172.31.39.46 timeout 6 retransmit 5 key rad123
```

Multiple RADIUS Servers with Global and Server-Specific Values Example

The following example shows how to configure two RADIUS servers with specific timeout, retransmit, and key values. In this example, the **aaa new-model** command enables AAA services on the router, while specific AAA commands define the AAA services. The **radius-server retransmit** command changes the global retransmission value to 4 for all RADIUS servers. The **radius-server host** command configures specific timeout, retransmission, and key values for the RADIUS server hosts with IP addresses 172.16.1.1 and 172.29.39.46.

```
! Enable AAA services on the router and define those services.
aaa new-model
aaa authentication login default group radius
aaa authentication login console-login none
aaa authentication ppp default group radius
aaa authorization network default group radius
aaa accounting exec default start-stop group radius
aaa accounting network default start-stop group radius
enable password tryit1
!
! Change the global retransmission value for all RADIUS servers.
radius-server retransmit 4
!
! Configure per-server specific timeout, retransmission, and key values.
! Change the default auth-port and acct-port values.
radius-server host 172.16.1.1 auth-port 1612 acct-port 1616 timeout 3 retransmit 3 key
radkey
!
! Configure per-server specific timeout and key values. This server uses the global
! retransmission value.
radius-server host 172.29.39.46 timeout 6 key rad123
```

Multiple RADIUS Server Entries for the Same Server IP Address Example

The following example shows how to configure the network access server to recognize several RADIUS host entries with the same IP address. Two different host entries on the same RADIUS server are configured for the same services—authentication and accounting. The second host entry configured acts as fail-over backup to the first one. (The RADIUS host entries will be tried in the order they are configured.)

```
! This command enables AAA.
aaa new-model
! The next command configures default RADIUS parameters.
aaa authentication ppp default group radius
! The next set of commands configures multiple host entries for the same IP address.
radius-server host 172.20.0.1 auth-port 1000 acct-port 1001
radius-server host 172.20.0.1 auth-port 2000 acct-port 2001
```

RADIUS Server Group Examples

The following example shows how to create server group *radgroup1* with three different RADIUS server members, each using the default authentication port (1645) and accounting port (1646):

```
aaa group server radius radgroup1
server 172.16.1.11
server 172.17.1.21
server 172.18.1.31
```

The following example shows how to create server group *radgroup2* with three RADIUS server members, each with the same IP address but with unique authentication and accounting ports:

```
aaa group server radius radgroup2
server 172.16.1.1 auth-port 1000 acct-port 1001
server 172.16.1.1 auth-port 2000 acct-port 2001
server 172.16.1.1 auth-port 3000 acct-port 3001
```

Multiple RADIUS Server Entries Using AAA Server Groups Example

The following example shows how to configure the network access server to recognize two different RADIUS server groups. One of these groups, *group1*, has two different host entries on the same RADIUS server configured for the same services. The second host entry configured acts as failover backup to the first one. Each group is individually configured for deadtime; deadtime for group 1 is one minute, and deadtime for group 2 is two minutes.

**Note**

In cases where both global commands and server commands are used, the server command will take precedence over the global command.

```
! This command enables AAA.
aaa new-model
! The next command configures default RADIUS parameters.
aaa authentication ppp default group group1
! The following commands define the group1 RADIUS server group and associate servers
! with it and configures a deadtime of one minute.
aaa group server radius group1
server 1.1.1.1 auth-port 1645 acct-port 1646
server 2.2.2.2 auth-port 2000 acct-port 2001
deadtime 1
```

```
! The following commands define the group2 RADIUS server group and associate servers
! with it and configures a deadtime of two minutes.
aaa group server radius group2
  server 2.2.2.2 auth-port 2000 acct-port 2001
  server 3.3.3.3 auth-port 1645 acct-port 1646
  deadtime 2
! The following set of commands configures the RADIUS attributes for each host entry
! associated with one of the defined server groups.
radius-server host 1.1.1.1 auth-port 1645 acct-port 1646
radius-server host 2.2.2.2 auth-port 2000 acct-port 2001
radius-server host 3.3.3.3 auth-port 1645 acct-port 1646
```

AAA Server Group Selection Based on DNIS Example

The following example shows how to select RADIUS server groups based on DNIS to provide specific AAA services:

```
! This command enables AAA.
aaa new-model
!
! The following set of commands configures the RADIUS attributes for each server
! that will be associated with one of the defined server groups.
radius-server host 172.16.0.1 auth-port 1645 acct-port 1646 key cisco1
radius-server host 172.17.0.1 auth-port 1645 acct-port 1646 key cisco2
radius-server host 172.18.0.1 auth-port 1645 acct-port 1646 key cisco3
radius-server host 172.19.0.1 auth-port 1645 acct-port 1646 key cisco4
radius-server host 172.20.0.1 auth-port 1645 acct-port 1646 key cisco5

! The following commands define the sg1 RADIUS server group and associate servers
! with it.
aaa group server radius sg1
  server 172.16.0.1
  server 172.17.0.1
! The following commands define the sg2 RADIUS server group and associate a server
! with it.
aaa group server radius sg2
  server 172.18.0.1
! The following commands define the sg3 RADIUS server group and associate a server
! with it.
aaa group server radius sg3
  server 172.19.0.1
! The following commands define the default-group RADIUS server group and associate
! a server with it.
aaa group server radius default-group
  server 172.20.0.1
!
! The next set of commands configures default-group RADIUS server group parameters.
aaa authentication ppp default group default-group
aaa accounting network default start-stop group default-group
!
```

```

! The next set of commands enables DNIS mapping and maps DNIS numbers to the defined
! RADIUS server groups. In this configuration, all PPP connection requests using
! DNIS 7777 are sent to the sg1 server group. The accounting records for these
! connections (specifically, start-stop records) are handled by the sg2 server group.
! Calls with a DNIS of 8888 use server group sg3 for authentication and server group
! default-group for accounting. Calls with a DNIS of 9999 use server group
! default-group for authentication and server group sg3 for accounting records
! (stop records only). All other calls with DNIS other than the ones defined use the
! server group default-group for both authentication and stop-start accounting records.
aaa dn timer enable
aaa dn timer map 7777 authentication ppp group sg1
aaa dn timer map 7777 accounting network start-stop group sg2
aaa dn timer map 8888 authentication ppp group sg3
aaa dn timer map 9999 accounting network stop-only group sg3

```

AAA Preauthentication Examples

The following example shows a simple configuration that specifies that the DNIS number be used for preauthentication:

```

aaa preauth
 group radius
 dn timer required

```

The following example shows a configuration that specifies that both the DNIS number and the CLID number be used for preauthentication. DNIS preauthentication will be performed first, followed by CLID preauthentication.

```

aaa preauth
 group radius
 dn timer required
 clid timer required

```

The following example specifies that preauthentication be performed on all DNIS numbers except the two DNIS numbers specified in the DNIS group called “hawaii”:

```

aaa preauth
 group radius
 dn timer required
 dn timer bypass hawaii

```

```

dialer dn timer group hawaii
 number 12345
 number 12346

```

The following example shows a sample AAA configuration with DNIS preauthentication:

```

aaa new-model
aaa authentication login CONSOLE none
aaa authentication login RADIUS_LIST group radius
aaa authentication login TAC_PLUS group tacacs+ enable
aaa authentication login V.120 none
aaa authentication enable default enable group tacacs+
aaa authentication ppp RADIUS_LIST if-needed group radius
aaa authorization exec RADIUS_LIST group radius if-authenticated
aaa authorization exec V.120 none
aaa authorization network default group radius if-authenticated
aaa authorization network RADIUS_LIST if-authenticated group radius
aaa authorization network V.120 group radius if-authenticated
aaa accounting suppress null-username
aaa accounting exec default start-stop group radius
aaa accounting commands 0 default start-stop group radius

```

```

aaa accounting network default start-stop group radius
aaa accounting connection default start-stop group radius
aaa accounting system default start-stop group radius
aaa preauth
  dnis password Cisco-DNIS
aaa nas port extended
!
radius-server configure-nas
radius-server host 10.0.0.0 auth-port 1645 acct-port 1646 non-standard
radius-server host 10.255.255.255 auth-port 1645 acct-port 1646 non-standard
radius-server retransmit 2
radius-server deadtime 1
radius-server attribute nas-port format c
radius-server unique-ident 18
radius-server key MyKey

```

**Note**

To configure preauthentication, you must also set up preauthentication profiles on the RADIUS server.

RADIUS User Profile with RADIUS Tunneling Attributes Example

The following example shows a RADIUS user profile (Merit Daemon format) that includes RADIUS tunneling attributes. This entry supports two tunnels, one for L2F and the other for L2TP. The tag entries with :1 support L2F tunnels, and the tag entries with :2 support L2TP tunnels.

```

cisco.com Password = "cisco", Service-Type = Outbound
  Service-Type = Outbound,
  Tunnel-Type = :1:L2F,
  Tunnel-Medium-Type = :1:IP,
  Tunnel-Client-Endpoint = :1:"10.0.0.2",
  Tunnel-Server-Endpoint = :1:"10.0.0.3",
  Tunnel-Client-Auth-Id = :1:"l2f-cli-auth-id",
  Tunnel-Server-Auth-Id = :1:"l2f-svr-auth-id",
  Tunnel-Assignment-Id = :1:"l2f-assignment-id",
  Cisco-Avpair = "vpdn:nas-password=l2f-cli-pass",
  Cisco-Avpair = "vpdn:gw-password=l2f-svr-pass",
  Tunnel-Preference = :1:1,
  Tunnel-Type = :2:L2TP,
  Tunnel-Medium-Type = :2:IP,
  Tunnel-Client-Endpoint = :2:"10.0.0.2",
  Tunnel-Server-Endpoint = :2:"10.0.0.3",
  Tunnel-Client-Auth-Id = :2:"l2tp-cli-auth-id",
  Tunnel-Server-Auth-Id = :2:"l2tp-svr-auth-id",
  Tunnel-Assignment-Id = :2:"l2tp-assignment-id",
  Cisco-Avpair = "vpdn:l2tp-tunnel-password=l2tp-tnl-pass",
  Tunnel-Preference = :2:2

```

Guard Timer Examples

The following example shows an ISDN guard timer that is set at 8000 milliseconds. A call will be rejected if the RADIUS server has not responded to a preauthentication request when the timer expires.

```
interface serial1/0/0:23
 isdn guard-timer 8000 on-expiry reject

aaa preauth
 group radius
 dnis required
```

The following example shows a CAS guard timer that is set at 20,000 milliseconds. A call will be accepted if the RADIUS server has not responded to a preauthentication request when the timer expires.

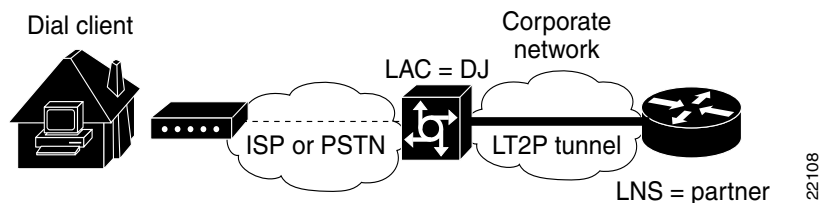
```
controller T1 0
 framing esf
 clock source line primary
 linecode b8zs
 ds0-group 0 timeslots 1-24 type e&m-fgb dtmf dnis
 cas-custom 0
 call guard-timer 20000 on-expiry accept

aaa preauth
 group radius
 dnis required
```

L2TP Access Concentrator Examples

The following example shows a basic L2TP configuration for the L2TP access concentrator (LAC) for the topology shown in [Figure 13](#). The local name is not defined, so the host name used is the local name. Because the L2TP tunnel password is not defined, the username password is used. In this example, VPDN is configured locally on the LAC and does not take advantage of the new RADIUS tunnel attributes.

Figure 13 Topology for Configuration Examples



```
! Enable AAA globally.
aaa new-model
! Enable AAA authentication for PPP and list the default method to use for PPP
! authentication.
aaa authentication ppp default local
! Define the username as "DJ."
username DJ password 7 030C5E070A00781B
! Enable VPDN.
vpdn enable
! Define VPDN group number 1.
vpdn-group 1
```



```
! Allow the LAC to respond to dialin requests using L2TP from IP address 172.21.9.13
! domain "cisco.com."
request dialin
protocol l2tp
domain cisco.com
initiate-ip to 172.21.9.13
local name nas-1
```

The following example shows how to configure the LAC if RADIUS tunnel attributes are supported. In this example, there is no local VPDN configuration on the LAC; the LAC, instead, is configured to query the remote RADIUS security server.

```
! Enable global AAA securities services.
aaa new-model
! Enable AAA authentication for PPP and list RADIUS as the default method to use
! for PPP authentication.
aaa authentication ppp default group radius local
! Enable AAA (network) authorization and list RADIUS as the default method to use for
! authorization.
aaa authorization network default group radius
! Define the username as "DJ."
username DJ password 7 030C5E070A00781B
! Enable VPDN.
vpdn enable
! Configure the LAC to interface with the remote RADIUS security server.
radius host 171.69.1.1 auth-port 1645 acct-port 1646
radius-server key cisco
```

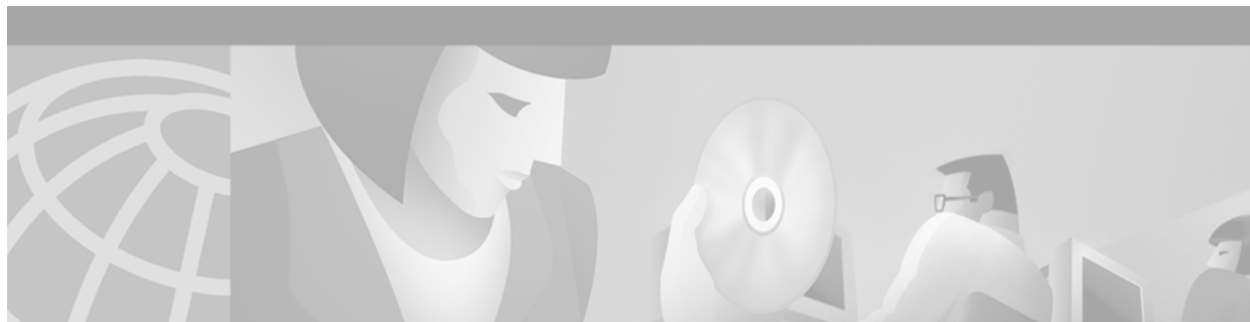
L2TP Network Server Examples

The following example shows a basic L2TP configuration with corresponding comments on the L2TP network server (LNS) for the topology shown in [Figure 13](#):

```
! Enable AAA globally.
aaa new-model
! Enable AAA authentication for PPP and list the default method to use for PPP
! authentication.
aaa authentication ppp default local
! Define the username as "partner."
username partner password 7 030C5E070A00781B
! Create virtual-template 1 and assign all values for virtual access interfaces.
interface Virtual-Template1
! Borrow the IP address from interface ethernet 1.
ip unnumbered Ethernet0
! Disable multicast fast switching.
no ip mroute-cache
! Use CHAP to authenticate PPP.
ppp authentication chap
! Enable VPDN.
vpdn enable
! Create vpdn-group number 1.
vpdn-group 1
! Accept all dialin l2tp tunnels from virtual-template 1 from remote peer DJ.
accept dialin l2tp virtual-template 1 remote DJ
protocol any
virtual-template 1
terminate-from hostname nas1
local name hgwl
```

The following example shows how to configure the LNS with a basic L2F and L2TP configuration using RADIUS tunneling attributes:

```
aaa new-model
aaa authentication login default none
aaa authentication login console none
aaa authentication ppp default local group radius
aaa authorization network default group radius if-authenticated
!
username l2f-cli-auth-id password 0 l2f-cli-pass
username l2f-svr-auth-id password 0 l2f-svr-pass
username l2tp-svr-auth-id password 0 l2tp-tnl-pass
!
vpdn enable
vpdn search-order domain
!
vpdn-group 1
accept-dialin
protocol l2f
virtual-template 1
terminate-from hostname l2f-cli-auth-id
local name l2f-svr-auth-id
!
vpdn-group 2
accept-dialin
protocol l2tp
virtual-template 2
terminate-from hostname l2tp-cli-auth-id
local name l2tp-svr-auth-id
!
interface Ethernet1/0
ip address 10.0.0.3 255.255.255.0
no ip route-cache
no ip mroute-cache
!
interface Virtual-Template1
ip unnumbered Ethernet1/0
ppp authentication pap
!
interface Virtual-Template2
ip unnumbered Ethernet1/0
ppp authentication pap
!
radius-server host 1.1.1.1 auth-port 1645 acct-port 1646
radius-server key <deleted>
!
```



Configuring TACACS+

This chapter discusses how to enable and configure TACACS+, which provides detailed accounting information and flexible administrative control over authentication and authorization processes. TACACS+ is facilitated through AAA and can be enabled only through AAA commands.

For a complete description of the TACACS+ commands used in this chapter, refer to the chapter “TACACS+ Commands” in the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature, or refer to the software release notes for a specific release. For more information, see the section “Identifying Supported Platforms” in the chapter “Using Cisco IOS Software.”

In This Chapter

This chapter includes the following sections:

- [About TACACS+](#)
- [TACACS+ Operation](#)
- [TACACS+ Configuration Task List](#)
- [TACACS+ AV Pairs](#)
- [TACACS+ Configuration Examples](#)

About TACACS+

TACACS+ is a security application that provides centralized validation of users attempting to gain access to a router or network access server. TACACS+ services are maintained in a database on a TACACS+ daemon running, typically, on a UNIX or Windows NT workstation. You must have access to and must configure a TACACS+ server before the configured TACACS+ features on your network access server are available.

TACACS+ provides for separate and modular authentication, authorization, and accounting facilities. TACACS+ allows for a single access control server (the TACACS+ daemon) to provide each service—authentication, authorization, and accounting—independently. Each service can be tied into its own database to take advantage of other services available on that server or on the network, depending on the capabilities of the daemon.

The goal of TACACS+ is to provide a methodology for managing multiple network access points from a single management service. The Cisco family of access servers and routers and the Cisco IOS user interface (for both routers and access servers) can be network access servers.

Network access points enable traditional “dumb” terminals, terminal emulators, workstations, personal computers (PCs), and routers in conjunction with suitable adapters (for example, modems or ISDN adapters) to communicate using protocols such as Point-to-Point Protocol (PPP), Serial Line Internet Protocol (SLIP), Compressed SLIP (CSLIP), or AppleTalk Remote Access (ARA) protocol. In other words, a network access server provides connections to a single user, to a network or subnetwork, and to interconnected networks. The entities connected to the network through a network access server are called *network access clients*; for example, a PC running PPP over a voice-grade circuit is a network access client. TACACS+, administered through the AAA security services, can provide the following services:

- **Authentication**—Provides complete control of authentication through login and password dialog, challenge and response, messaging support.

The authentication facility provides the ability to conduct an arbitrary dialog with the user (for example, after a login and password are provided, to challenge a user with a number of questions, like home address, mother’s maiden name, service type, and social security number). In addition, the TACACS+ authentication service supports sending messages to user screens. For example, a message could notify users that their passwords must be changed because of the company’s password aging policy.

- **Authorization**—Provides fine-grained control over user capabilities for the duration of the user’s session, including but not limited to setting autocommands, access control, session duration, or protocol support. You can also enforce restrictions on what commands a user may execute with the TACACS+ authorization feature.
- **Accounting**—Collects and sends information used for billing, auditing, and reporting to the TACACS+ daemon. Network managers can use the accounting facility to track user activity for a security audit or to provide information for user billing. Accounting records include user identities, start and stop times, executed commands (such as PPP), number of packets, and number of bytes.

The TACACS+ protocol provides authentication between the network access server and the TACACS+ daemon, and it ensures confidentiality because all protocol exchanges between a network access server and a TACACS+ daemon are encrypted.

You need a system running TACACS+ daemon software to use the TACACS+ functionality on your network access server.

Cisco makes the TACACS+ protocol specification available as a draft RFC for those customers interested in developing their own TACACS+ software.

TACACS+ Operation

When a user attempts a simple ASCII login by authenticating to a network access server using TACACS+, the following process typically occurs:

1. When the connection is established, the network access server will contact the TACACS+ daemon to obtain a username prompt, which is then displayed to the user. The user enters a username and the network access server then contacts the TACACS+ daemon to obtain a password prompt. The network access server displays the password prompt to the user, the user enters a password, and the password is then sent to the TACACS+ daemon.

**Note**

TACACS+ allows an arbitrary conversation to be held between the daemon and the user until the daemon receives enough information to authenticate the user. This is usually done by prompting for a username and password combination, but may include other items, such as mother's maiden name, all under the control of the TACACS+ daemon.

2. The network access server will eventually receive one of the following responses from the TACACS+ daemon:
 - a. **ACCEPT**—The user is authenticated and service may begin. If the network access server is configured to require authorization, authorization will begin at this time.
 - b. **REJECT**—The user has failed to authenticate. The user may be denied further access, or will be prompted to retry the login sequence depending on the TACACS+ daemon.
 - c. **ERROR**—An error occurred at some time during authentication. This can be either at the daemon or in the network connection between the daemon and the network access server. If an **ERROR** response is received, the network access server will typically try to use an alternative method for authenticating the user.
 - d. **CONTINUE**—The user is prompted for additional authentication information.
3. A PAP login is similar to an ASCII login, except that the username and password arrive at the network access server in a PAP protocol packet instead of being typed in by the user, so the user is not prompted. PPP CHAP logins are also similar in principle.

Following authentication, the user will also be required to undergo an additional authorization phase, if authorization has been enabled on the network access server. Users must first successfully complete TACACS+ authentication before proceeding to TACACS+ authorization.

4. If TACACS+ authorization is required, the TACACS+ daemon is again contacted and it returns an **ACCEPT** or **REJECT** authorization response. If an **ACCEPT** response is returned, the response will contain data in the form of attributes that are used to direct the **EXEC** or **NETWORK** session for that user, determining services that the user can access.

Services include the following:

- a. Telnet, rlogin, Point-to-Point Protocol (PPP), Serial Line Internet Protocol (SLIP), or **EXEC** services
- b. Connection parameters, including the host or client IP address, access list, and user timeouts

TACACS+ Configuration Task List

To configure your router to support TACACS+, you must perform the following tasks:

- Use the **aaa new-model** global configuration command to enable AAA. AAA must be configured if you plan to use TACACS+. For more information about using the **aaa new-model** command, refer to the chapter “AAA Overview”.
- Use the **tacacs-server host** command to specify the IP address of one or more TACACS+ daemons. Use the **tacacs-server key** command to specify an encryption key that will be used to encrypt all exchanges between the network access server and the TACACS+ daemon. This same key must also be configured on the TACACS+ daemon.
- Use the **aaa authentication** global configuration command to define method lists that use TACACS+ for authentication. For more information about using the **aaa authentication** command, refer to the chapter “Configuring Authentication”.

- Use **line** and **interface** commands to apply the defined method lists to various interfaces. For more information, refer to the chapter “Configuring Authentication”.
- If needed, use the **aaa authorization** global command to configure authorization for the network access server. Unlike authentication, which can be configured per line or per interface, authorization is configured globally for the entire network access server. For more information about using the **aaa authorization** command, refer to the “Configuring Authorization” chapter.
- If needed, use the **aaa accounting** command to enable accounting for TACACS+ connections. For more information about using the **aaa accounting** command, refer to the “Configuring Accounting” chapter.

To configure TACACS+, perform the tasks in the following sections:

- [Identifying the TACACS+ Server Host](#) (Required)
- [Setting the TACACS+ Authentication Key](#) (Optional)
- [Configuring AAA Server Groups](#) (Optional)
- [Configuring AAA Server Group Selection Based on DNIS](#) (Optional)
- [Specifying TACACS+ Authentication](#) (Required)
- [Specifying TACACS+ Authorization](#) (Optional)
- [Specifying TACACS+ Accounting](#) (Optional)

For TACACS+ configuration examples using the commands in this chapter, refer to the “[TACACS+ Configuration Examples](#)” section at the end of this chapter.

Identifying the TACACS+ Server Host

The **tacacs-server host** command enables you to specify the names of the IP host or hosts maintaining a TACACS+ server. Because the TACACS+ software searches for the hosts in the order specified, this feature can be useful for setting up a list of preferred daemons.

To specify a TACACS+ host, use the following command in global configuration mode:

Command	Purpose
Router(config)# tacacs-server host <i>hostname</i> [single-connection] [port <i>integer</i>] [timeout <i>integer</i>] [key <i>string</i>]	Specifies a TACACS+ host.

Using the **tacacs-server host** command, you can also configure the following options:

- Use the **single-connection** keyword to specify single-connection (only valid with CiscoSecure Release 1.0.1 or later). Rather than have the router open and close a TCP connection to the daemon each time it must communicate, the single-connection option maintains a single open connection between the router and the daemon. This is more efficient because it allows the daemon to handle a higher number of TACACS operations.



Note

The daemon must support single-connection mode for this to be effective, otherwise the connection between the network access server and the daemon will lock up or you will receive spurious errors.

- Use the **port** *integer* argument to specify the TCP port number to be used when making connections to the TACACS+ daemon. The default port number is 49.
- Use the **timeout** *integer* argument to specify the period of time (in seconds) the router will wait for a response from the daemon before it times out and declares an error.

**Note**

Specifying the timeout value with the **tacacs-server host** command overrides the default timeout value set with the **tacacs-server timeout** command for this server only.

- Use the **key** *string* argument to specify an encryption key for encrypting and decrypting all traffic between the network access server and the TACACS+ daemon.

**Note**

Specifying the encryption key with the **tacacs-server host** command overrides the default key set by the global configuration **tacacs-server key** command for this server only.

Because some of the parameters of the **tacacs-server host** command override global settings made by the **tacacs-server timeout** and **tacacs-server key** commands, you can use this command to enhance security on your network by uniquely configuring individual TACACS+ connections.

Setting the TACACS+ Authentication Key

To set the global TACACS+ authentication key and encryption key, use the following command in global configuration mode:

Command	Purpose
Router(config)# tacacs-server key <i>key</i>	Sets the encryption key to match that used on the TACACS+ daemon.

**Note**

You must configure the same key on the TACACS+ daemon for encryption to be successful.

Configuring AAA Server Groups

Configuring the router to use AAA server groups provides a way to group existing server hosts. This allows you to select a subset of the configured server hosts and use them for a particular service. A server group is used in conjunction with a global server-host list. The server group lists the IP addresses of the selected server hosts.

Server groups can include multiple host entries as long as each entry has a unique IP address. If two different host entries in the server group are configured for the same service—for example, accounting—the second host entry configured acts as fail-over backup to the first one. Using this example, if the first host entry fails to provide accounting services, the network access server will try the second host entry for accounting services. (The TACACS+ host entries will be tried in the order in which they are configured.)

To define a server host with a server group name, enter the following commands starting in global configuration mode. The listed server must exist in global configuration mode:

	Command	Purpose
Step 1	Router(config)# tacacs-server host <i>name</i> [single-connection] [port <i>integer</i>] [timeout <i>integer</i>] [key <i>string</i>]	Specifies and defines the IP address of the server host before configuring the AAA server-group. Refer to the “ Identifying the TACACS+ Server Host ” section of this chapter for more information on the tacacs-server host command.
Step 2	Router(config-if)# aaa group server { radius tacacs+ } <i>group-name</i>	Defines the AAA server-group with a group name. All members of a group must be the same type; that is, RADIUS or TACACS+. This command puts the router in server group subconfiguration mode.
Step 3	Router(config-sg)# server <i>ip-address</i> [auth-port <i>port-number</i>] [acct-port <i>port-number</i>]	Associates a particular TACACS+ server with the defined server group. Use the auth-port <i>port-number</i> option to configure a specific UDP port solely for authentication. Use the acct-port <i>port-number</i> option to configure a specific UDP port solely for accounting. Repeat this step for each TACACS+ server in the AAA server group. Note Each server in the group must be defined previously using the tacacs-server host command.

Configuring AAA Server Group Selection Based on DNIS

Cisco IOS software allows you to authenticate users to a particular AAA server group based on the Dialed Number Identification Service (DNIS) number of the session. Any phone line (a regular home phone or a commercial T1/PRI line) can be associated with several phone numbers. The DNIS number identifies the number that was called to reach you.

For example, suppose you want to share the same phone number with several customers, but you want to know which customer is calling before you pick up the phone. You can customize how you answer the phone because DNIS allows you to know which customer is calling when you answer.

Cisco routers with either ISDN or internal modems can receive the DNIS number. This functionality allows users to assign different TACACS+ server groups for different customers (that is, different TACACS+ servers for different DNIS numbers). Additionally, using server groups you can specify the same server group for AAA services or a separate server group for each AAA service.

Cisco IOS software provides the flexibility to implement authentication and accounting services in several ways:

- Globally—AAA services are defined using global configuration access list commands and applied in general to all interfaces on a specific network access server.
- Per interface—AAA services are defined using interface configuration commands and applied specifically to the interface being configured on a specific network access server.
- DNIS mapping—You can use DNIS to specify an AAA server to supply AAA services.

Because AAA configuration methods can be configured simultaneously, Cisco has established an order of precedence to determine which server or groups of servers provide AAA services. The order of precedence is as follows:

- Per DNIS—If you configure the network access server to use DNIS to identify which server group provides AAA services, then this method takes precedence over any additional AAA selection method.
- Per interface—If you configure the network access server per interface to use access lists to determine how a server provides AAA services, this method takes precedence over any global configuration AAA access lists.
- Globally—If you configure the network access server by using global AAA access lists to determine how the security server provides AAA services, this method has the lowest precedence.



Note

Prior to configuring AAA Server Group Selection Based on DNIS, you must configure the remote security servers associated with each AAA server group. See the sections [“Identifying the TACACS+ Server Host”](#) and [“Configuring AAA Server Groups”](#) in this chapter.

To configure the router to select a particular AAA server group based on the DNIS of the server group, configure DNIS mapping. To map a server group with a group name with DNIS number, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# aaa dnis map enable	Enables DNIS mapping.
Step 2	Router(config)# aaa dnis map <i>dnis-number</i> authentication ppp group <i>server-group-name</i>	Maps a DNIS number to a defined AAA server group; the servers in this server group are being used for authentication.
Step 3	Router(config)# aaa dnis map <i>dnis-number</i> accounting network [none start-stop stop-only] group <i>server-group-name</i>	Maps a DNIS number to a defined AAA server group; the servers in this server group are being used for accounting.

Specifying TACACS+ Authentication

After you have identified the TACACS+ daemon and defined an associated TACACS+ encryption key, you must define method lists for TACACS+ authentication. Because TACACS+ authentication is operated via AAA, you need to issue the **aaa authentication** command, specifying TACACS+ as the authentication method. For more information, refer to the chapter “Configuring Authentication.”

Specifying TACACS+ Authorization

AAA authorization enables you to set parameters that restrict a user’s access to the network. Authorization via TACACS+ may be applied to commands, network connections, and EXEC sessions. Because TACACS+ authorization is facilitated through AAA, you must issue the **aaa authorization** command, specifying TACACS+ as the authorization method. For more information, refer to the chapter “Configuring Authorization.”

Specifying TACACS+ Accounting

AAA accounting enables you to track the services users are accessing as well as the amount of network resources they are consuming. Because TACACS+ accounting is facilitated through AAA, you must issue the **aaa accounting** command, specifying TACACS+ as the accounting method. For more information, refer to the chapter “Configuring Accounting.”

TACACS+ AV Pairs

The network access server implements TACACS+ authorization and accounting functions by transmitting and receiving TACACS+ attribute-value (AV) pairs for each user session. For a list of supported TACACS+ AV pairs, refer to the appendix “TACACS+ Attribute-Value Pairs.”

TACACS+ Configuration Examples

The following sections provide TACACS+ configuration examples:

- [TACACS+ Authentication Examples](#)
- [TACACS+ Authorization Example](#)
- [TACACS+ Accounting Example](#)
- [TACACS+ Server Group Example](#)
- [AAA Server Group Selection Based on DNIS Example](#)
- [TACACS+ Daemon Configuration Example](#)

TACACS+ Authentication Examples

The following example shows how to configure TACACS+ as the security protocol for PPP authentication:

```
aaa new-model
aaa authentication ppp test group tacacs+ local
tacacs-server host 10.1.2.3
tacacs-server key goaway
interface serial 0
  ppp authentication chap pap test
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines a method list, “test,” to be used on serial interfaces running PPP. The keyword **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.1.2.3. The **tacacs-server key** command defines the shared encryption key to be “goaway.”
- The **interface** command selects the line, and the **ppp authentication** command applies the test method list to this line.

The following example shows how to configure TACACS+ as the security protocol for PPP authentication, but instead of the “test” method list, the “default” method list is used.

```
aaa new-model
aaa authentication ppp default if-needed group tacacs+ local
tacacs-server host 10.1.2.3
tacacs-server key goaway
interface serial 0
  ppp authentication chap default
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines a method list, “default,” to be used on serial interfaces running PPP. The keyword **default** means that PPP authentication is applied by default to all interfaces. The **if-needed** keyword means that if the user has already authenticated by going through the ASCII login procedure, then PPP authentication is not necessary and can be skipped. If authentication is needed, the keyword **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.1.2.3. The **tacacs-server key** command defines the shared encryption key to be “goaway.”
- The **interface** command selects the line, and the **ppp authentication** command applies the default method list to this line.

The following example shows how to create the same authentication algorithm for PAP, but it calls the method list “MIS-access” instead of “default”:

```
aaa new-model
aaa authentication pap MIS-access if-needed group tacacs+ local
tacacs-server host 10.1.2.3
tacacs-server key goaway
interface serial 0
  ppp authentication pap MIS-access
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines a method list, “MIS-access,” to be used on serial interfaces running PPP. The method list, “MIS-access,” means that PPP authentication is applied to all interfaces. The **if-needed** keyword means that if the user has already authenticated by going through the ASCII login procedure, then PPP authentication is not necessary and can be skipped. If authentication is needed, the keyword **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.1.2.3. The **tacacs-server key** command defines the shared encryption key to be “goaway.”
- The **interface** command selects the line, and the **ppp authentication** command applies the default method list to this line.

The following example shows the configuration for a TACACS+ daemon with an IP address of 10.2.3.4 and an encryption key of “apple”:

```
aaa new-model
aaa authentication login default group tacacs+ local
tacacs-server host 10.2.3.4
tacacs-server key apple
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines the default method list. Incoming ASCII logins on all interfaces (by default) will use TACACS+ for authentication. If no TACACS+ server responds, then the network access server will use the information contained in the local username database for authentication.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.2.3.4. The **tacacs-server key** command defines the shared encryption key to be “apple.”

TACACS+ Authorization Example

The following example shows how to configure TACACS+ as the security protocol for PPP authentication using the default method list; it also shows how to configure network authorization via TACACS+:

```
aaa new-model
aaa authentication ppp default if-needed group tacacs+ local
aaa authorization network default group tacacs+
tacacs-server host 10.1.2.3
tacacs-server key goaway
interface serial 0
  ppp authentication chap default
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines a method list, “default,” to be used on serial interfaces running PPP. The keyword **default** means that PPP authentication is applied by default to all interfaces. The **if-needed** keyword means that if the user has already authenticated by going through the ASCII login procedure, then PPP authentication is not necessary and can be skipped. If authentication is needed, the keyword **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.
- The **aaa authorization** command configures network authorization via TACACS+. Unlike authentication lists, this authorization list always applies to all incoming network connections made to the network access server.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.1.2.3. The **tacacs-server key** command defines the shared encryption key to be “goaway.”
- The **interface** command selects the line, and the **ppp authentication** command applies the default method list to this line.

TACACS+ Accounting Example

The following example shows how to configure TACACS+ as the security protocol for PPP authentication using the default method list; it also shows how to configure accounting via TACACS+:

```
aaa new-model
aaa authentication ppp default if-needed group tacacs+ local
aaa accounting network default stop-only group tacacs+
tacacs-server host 10.1.2.3
tacacs-server key goaway
interface serial 0
  ppp authentication chap default
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines a method list, “default,” to be used on serial interfaces running PPP. The keyword **default** means that PPP authentication is applied by default to all interfaces. The **if-needed** keyword means that if the user has already authenticated by going through the ASCII login procedure, then PPP authentication is not necessary and can be skipped. If authentication is needed, the keyword **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.
- The **aaa accounting** command configures network accounting via TACACS+. In this example, accounting records describing the session that just terminated will be sent to the TACACS+ daemon whenever a network connection terminates.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.1.2.3. The **tacacs-server key** command defines the shared encryption key to be “goaway.”
- The **interface** command selects the line, and the **ppp authentication** command applies the default method list to this line.

TACACS+ Server Group Example

The following example shows how to create a server group with three different TACACS+ servers members:

```
aaa group server tacacs tacgroup1
  server 172.16.1.1
  server 172.16.1.21
  server 172.16.1.31
```

AAA Server Group Selection Based on DNIS Example

The following example shows how to select TACACS+ server groups based on DNIS to provide specific AAA services:

```
! This command enables AAA.
aaa new-model
!
! The following set of commands configures the TACACS+ servers that will be associated
! with one of the defined server groups.
tacacs-server host 172.16.0.1
tacacs-server host 172.17.0.1
```

```

tacacs-server host 172.18.0.1
tacacs-server host 172.19.0.1
tacacs-server host 172.20.0.1
tacacs-server key abcdefg

! The following commands define the sg1 TACACS+ server group and associate servers
! with it.
aaa group server tacacs sg1
    server 172.16.0.1
    server 172.17.0.1
! The following commands define the sg2 TACACS+ server group and associate a server
! with it.
aaa group server tacacs sg2
    server 172.18.0.1
! The following commands define the sg3 TACACS+ server group and associate a server
! with it.
aaa group server tacacs sg3
    server 172.19.0.1
! The following commands define the default-group TACACS+ server group and associate
! a server with it.
aaa group server tacacs default-group
    server 172.20.0.1
!
! The next set of commands configures default-group tacacs server group parameters.
aaa authentication ppp default group default-group
aaa accounting network default start-stop group default-group
!
! The next set of commands enables DNIS mapping and maps DNIS numbers to the defined
! RADIUS server groups. In this configuration, all PPP connection requests using DNIS
! 7777 are sent to the sg1 server group. The accounting records for these connections
! (specifically, start-stop records) are handled by the sg2 server group. Calls with a
! DNIS of 8888 use server group sg3 for authentication and server group default-group
! for accounting. Calls with a DNIS of 9999 use server group default-group for
! authentication and server group sg3 for accounting records (stop records only). All
! other calls with DNIS other than the ones defined use the server group default-group
! for both authentication and stop-start accounting records.
aaa dn timer enable
aaa dn timer 7777 authentication ppp group sg1
aaa dn timer 7777 accounting network start-stop group sg2
aaa dn timer 8888 authentication ppp group sg3
aaa dn timer 9999 accounting network stop-only group sg3

```

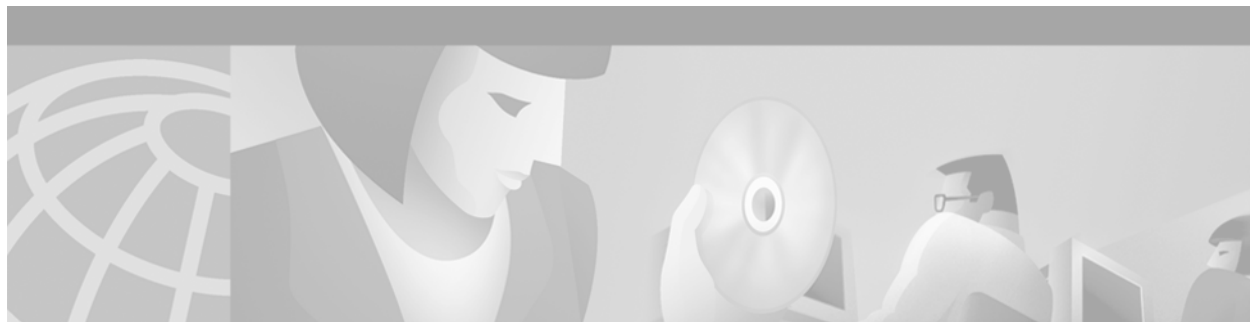
TACACS+ Daemon Configuration Example

The following example shows a sample configuration of the TACACS+ daemon. The precise syntax used by your TACACS+ daemon may be different from what is included in this example.

```

user = mci_customer1 {
    chap = cleartext "some chap password"
    service = ppp protocol = ip {
        inacl#1="permit ip any any precedence immediate"
        inacl#2="deny igmp 0.0.1.2 255.255.0.0 any"
    }
}

```



Configuring Kerberos

This chapter describes the Kerberos security system. For a complete description of the Kerberos commands used in this chapter, refer to the “Kerberos Commands” chapter in the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature, or refer to the software release notes for a specific release. For more information, see the section “Identifying Supported Platforms” in the chapter “Using Cisco IOS Software.”

In This Chapter

This chapter includes the following topics and tasks:

- [About Kerberos](#)
- [Kerberos Client Support Operation](#)
- [Kerberos Configuration Task List](#)
- [Kerberos Configuration Examples](#)

About Kerberos

Kerberos is a secret-key network authentication protocol, developed at the Massachusetts Institute of Technology (MIT), that uses the Data Encryption Standard (DES) cryptographic algorithm for encryption and authentication. Kerberos was designed to authenticate requests for network resources. Kerberos, like other secret-key systems, is based on the concept of a trusted third party that performs secure verification of users and services. In the Kerberos protocol, this trusted third party is called the key distribution center (KDC).

The primary use of Kerberos is to verify that users and the network services they use are really who and what they claim to be. To accomplish this, a trusted Kerberos server issues tickets to users. These tickets, which have a limited lifespan, are stored in a user’s credential cache and can be used in place of the standard username-and-password authentication mechanism.

The Kerberos credential scheme embodies a concept called “single logon.” This process requires authenticating a user once, and then allows secure authentication (without encrypting another password) wherever that user’s credential is accepted.

Starting with Cisco IOS Release 11.2, Cisco IOS software includes Kerberos 5 support, which allows organizations already deploying Kerberos 5 to use the same Kerberos authentication database on their routers that they are already using on their other network hosts (such as UNIX servers and PCs).

The following network services are supported by the Kerberos authentication capabilities in Cisco IOS software:

- Telnet
- rlogin
- rsh
- rcp

**Note**

Cisco Systems' implementation of Kerberos client support is based on code developed by CyberSafe, which was derived from the MIT code. As a result, the Cisco Kerberos implementation has successfully undergone full compatibility testing with the CyberSafe Challenger commercial Kerberos server and MIT's server code, which is freely distributed.

Table 14 lists common Kerberos-related terms and their definitions.

Table 14 Kerberos Terminology

Term	Definition
authentication	A process by which a user or service identifies itself to another service. For example, a client can authenticate to a router or a router can authenticate to another router.
authorization	A means by which the router determines what privileges you have in a network or on the router and what actions you can perform.
credential	A general term that refers to authentication tickets, such as ticket granting tickets (TGTs) and service credentials. Kerberos credentials verify the identity of a user or service. If a network service decides to trust the Kerberos server that issued a ticket, it can be used in place of retyping in a username and password. Credentials have a default lifespan of eight hours.
instance	An authorization level label for Kerberos principals. Most Kerberos principals are of the form user@REALM (for example, smith@EXAMPLE.COM). A Kerberos principal with a Kerberos instance has the form user/instance@REALM (for example, smith/admin@EXAMPLE.COM). The Kerberos instance can be used to specify the authorization level for the user if authentication is successful. It is up to the server of each network service to implement and enforce the authorization mappings of Kerberos instances. Note that the Kerberos realm name must be in uppercase characters.
Kerberized	Applications and services that have been modified to support the Kerberos credential infrastructure.
Kerberos realm	A domain consisting of users, hosts, and network services that are registered to a Kerberos server. The Kerberos server is trusted to verify the identity of a user or network service to another user or network service. Kerberos realms must always be in uppercase characters.
Kerberos server	A daemon running on a network host. Users and network services register their identity with the Kerberos server. Network services query the Kerberos server to authenticate to other network services.

Table 14 *Kerberos Terminology (continued)*

Term	Definition
key distribution center (KDC)	A Kerberos server and database program running on a network host.
principal	Also known as a Kerberos identity, this is who you are or what a service is according to the Kerberos server.
service credential	A credential for a network service. When issued from the KDC, this credential is encrypted with the password shared by the network service and the KDC, and with the user's TGT.
SRVTAB	A password that a network service shares with the KDC. The network service authenticates an encrypted service credential by using the SRVTAB (also known as a KEYTAB) to decrypt it.
ticket granting ticket (TGT)	A credential that the key distribution center (KDC) issues to authenticated users. When users receive a TGT, they can authenticate to network services within the Kerberos realm represented by the KDC.

Kerberos Client Support Operation

This section describes how the Kerberos security system works with a Cisco router functioning as the security server. Although (for convenience or technical reasons) you can customize Kerberos in a number of ways, remote users attempting to access network services must pass through three layers of security before they can access network services.

This section includes the following sections:

- [Authenticating to the Boundary Router](#)
- [Obtaining a TGT from a KDC](#)
- [Authenticating to Network Services](#)

Authenticating to the Boundary Router

This section describes the first layer of security that remote users must pass through when they attempt to access a network. The first step in the Kerberos authentication process is for users to authenticate themselves to the boundary router. The following process describes how users authenticate to a boundary router:

1. The remote user opens a PPP connection to the corporate site router.
2. The router prompts the user for a username and password.
3. The router requests a TGT from the KDC for this particular user.
4. The KDC sends an encrypted TGT to the router that includes (among other things) the user's identity.
5. The router attempts to decrypt the TGT using the password the user entered. If the decryption is successful, the remote user is authenticated to the router.

A remote user who successfully initiates a PPP session and authenticates to the boundary router is inside the firewall but still must authenticate to the KDC directly before being allowed to access network services. This is because the TGT issued by the KDC is stored on the router and is not useful for additional authentication unless the user physically logs on to the router.

Obtaining a TGT from a KDC

This section describes how remote users who are authenticated to the boundary router authenticate themselves to a KDC.

When a remote user authenticates to a boundary router, that user technically becomes part of the network; that is, the network is extended to include the remote user and the user's machine or network. To gain access to network services, however, the remote user must obtain a TGT from the KDC. The following process describes how remote users authenticate to the KDC:

1. The remote user, at a workstation on a remote site, launches the KINIT program (part of the client software provided with the Kerberos protocol).
2. The KINIT program finds the user's identity and requests a TGT from the KDC.
3. The KDC creates a TGT, which contains the identity of the user, the identity of the KDC, and the expiration time of the TGT.
4. Using the user's password as a key, the KDC encrypts the TGT and sends the TGT to the workstation.
5. When the KINIT program receives the encrypted TGT, it prompts the user for a password (this is the password that is defined for the user in the KDC).
6. If the KINIT program can decrypt the TGT with the password the user enters, the user is authenticated to the KDC, and the KINIT program stores the TGT in the user's credential cache.

At this point, the user has a TGT and can communicate securely with the KDC. In turn, the TGT allows the user to authenticate to other network services.

Authenticating to Network Services

The following process describes how a remote user with a TGT authenticates to network services within a given Kerberos realm. Assume the user is on a remote workstation (Host A) and wants to log in to Host B.

1. The user on Host A initiates a Kerberized application (such as Telnet) to Host B.
2. The Kerberized application builds a service credential request and sends it to the KDC. The service credential request includes (among other things) the user's identity and the identity of the desired network service. The TGT is used to encrypt the service credential request.
3. The KDC tries to decrypt the service credential request with the TGT it issued to the user on Host A. If the KDC can decrypt the packet, it is assured that the authenticated user on Host A sent the request.
4. The KDC notes the network service identity in the service credential request.
5. The KDC builds a service credential for the appropriate network service on Host B on behalf of the user on Host A. The service credential contains the client's identity and the desired network service's identity.

6. The KDC then encrypts the service credential twice. It first encrypts the credential with the SRVTAB that it shares with the network service identified in the credential. It then encrypts the resulting packet with the TGT of the user (who, in this case, is on Host A).
7. The KDC sends the twice-encrypted credential to Host A.
8. Host A attempts to decrypt the service credential with the user's TGT. If Host A can decrypt the service credential, it is assured the credential came from the real KDC.
9. Host A sends the service credential to the desired network service. Note that the credential is still encrypted with the SRVTAB shared by the KDC and the network service.
10. The network service attempts to decrypt the service credential using its SRVTAB.
11. If the network service can decrypt the credential, it is assured the credential was in fact issued from the KDC. Note that the network service trusts anything it can decrypt from the KDC, even if it receives it indirectly from a user. This is because the user first authenticated with the KDC.

At this point, the user is authenticated to the network service on Host B. This process is repeated each time a user wants to access a network service in the Kerberos realm.

Kerberos Configuration Task List

For hosts and the KDC in your Kerberos realm to communicate and mutually authenticate, you must identify them to each other. To do this, you add entries for the hosts to the Kerberos database on the KDC and add SRVTAB files generated by the KDC to all hosts in the Kerberos realm. You also make entries for users in the KDC database.

This section describes how to set up a Kerberos-authenticated server-client system and contains the following topics:

- [Configuring the KDC Using Kerberos Commands](#)
- [Configuring the Router to Use the Kerberos Protocol](#)

This section assumes that you have installed the Kerberos administrative programs on a UNIX host, known as the KDC, initialized the database, and selected a Kerberos realm name and password. For instructions about completing these tasks, refer to documentation that came with your Kerberos software.

**Note**

Write down the host name or IP address of the KDC, the port number you want the KDC to monitor for queries, and the name of the Kerberos realm it will serve. You need this information to configure the router.

Configuring the KDC Using Kerberos Commands

After you set up a host to function as the KDC in your Kerberos realm, you must make entries to the KDC database for all principals in the realm. Principals can be network services on Cisco routers and hosts or they can be users.

To use Kerberos commands to add services to the KDC database (and to modify existing database information), complete the tasks in the following sections:

- [Adding Users to the KDC Database](#)
- [Creating SRVTABs on the KDC](#)
- [Extracting SRVTABs](#)

**Note**

All Kerberos command examples are based on Kerberos 5 Beta 5 of the original MIT implementation. Later versions use a slightly different interface.

Adding Users to the KDC Database

To add users to the KDC and create privileged instances of those users, use the **su** command to become root on the host running the KDC and use the `kdb5_edit` program to use the following commands in privileged EXEC mode:

	Command	Purpose
Step 1	Router# ank <i>username@REALM</i>	Use the ank (add new key) command to add a user to the KDC. This command prompts for a password, which the user must enter to authenticate to the router.
Step 2	Router# ank <i>username/instance@REALM</i>	Use the ank command to add a privileged instance of a user.

For example, to add user *loki* of Kerberos realm CISCO.COM, enter the following Kerberos command:

```
ank loki@CISCO.COM
```

**Note**

The Kerberos realm name must be in uppercase characters.

You might want to create privileged instances to allow network administrators to connect to the router at the enable level, for example, so that they need not enter a clear text password (and compromise security) to enter enable mode.

To add an instance of *loki* with additional privileges (in this case, *enable*, although it could be anything) enter the following Kerberos command:

```
ank loki/enable@CISCO.COM
```

In each of these examples, you are prompted to enter a password, which you must give to user *loki* to use at login.

The “[Enabling Kerberos Instance Mapping](#)” section describes how to map Kerberos instances to various Cisco IOS privilege levels.

Creating SRVTABs on the KDC

All routers that you want to authenticate to use the Kerberos protocol must have an SRVTAB. This section and the “[Extracting SRVTABs](#)” section describe how to create and extract SRVTABs for a router called *router1*. The section “[Copying SRVTAB Files](#)” describes how to copy SRVTAB files to the router.

To make SRVTAB entries on the KDC, use the following command in privileged EXEC mode:

Command	Purpose
Router# ark <i>SERVICE/HOSTNAME@REALM</i>	Use the ark (add random key) command to add a network service supported by a host or router to the KDC.

For example, to add a Kerberized authentication service for a Cisco router called *router1* to the Kerberos realm CISCO.COM, enter the following Kerberos command:

```
ark host/router1.cisco.com@CISCO.COM
```

Make entries for all network services on all Kerberized hosts that use this KDC for authentication.

Extracting SRVTABs

SRVTABs contain (among other things) the passwords or randomly generated keys for the service principals you entered into the KDC database. Service principal keys must be shared with the host running that service. To do this, you must save the SRVTAB entries to a file, then copy the file to the router and all hosts in the Kerberos realm. Saving SRVTAB entries to a file is called *extracting* SRVTABs. To extract SRVTABs, use the following command in privileged EXEC mode:

Command	Purpose
Router# xst <i>router-name host</i>	Use the kdb5_edit command xst to write an SRVTAB entry to a file.

For example, to write the host/router1.cisco.com@CISCO.COM SRVTAB to a file, enter the following Kerberos command:

```
xst router1.cisco.com@CISCO.COM host
```

Use the **quit** command to exit the kdb5_edit program.

Configuring the Router to Use the Kerberos Protocol

To configure a Cisco router to function as a network security server and authenticate users using the Kerberos protocol, complete the tasks in the following sections:

- [Defining a Kerberos Realm](#)
- [Copying SRVTAB Files](#)
- [Specifying Kerberos Authentication](#)
- [Enabling Credentials Forwarding](#)
- [Opening a Telnet Session to the Router](#)
- [Establishing an Encrypted Kerberized Telnet Session](#)
- [Enabling Mandatory Kerberos Authentication](#)
- [Enabling Kerberos Instance Mapping](#)
- [Monitoring and Maintaining Kerberos](#)

Defining a Kerberos Realm

For a router to authenticate a user defined in the Kerberos database, it must know the host name or IP address of the host running the KDC, the name of the Kerberos realm and, optionally, be able to map the host name or Domain Name System (DNS) domain to the Kerberos realm.

To configure the router to authenticate to a specified KDC in a specified Kerberos realm, use the following commands in global configuration mode. Note that DNS domain names must begin with a leading dot (.):

	Command	Purpose
Step 1	Router(config)# kerberos local-realm <i>kerberos-realm</i>	Defines the default realm for the router.
Step 2	Router(config)# kerberos server <i>kerberos-realm</i> { <i>hostname</i> <i>ip-address</i> } [<i>port-number</i>]	Specifies to the router which KDC to use in a given Kerberos realm and, optionally, the port number that the KDC is monitoring. (The default is 88.)
Step 3	Router(config)# kerberos realm { <i>dns-domain</i> <i>host</i> } <i>kerberos-realm</i>	(Optional) Maps a host name or DNS domain to a Kerberos realm.



Note

Because the machine running the KDC and all Kerberized hosts must interact within a 5-minute window or authentication fails, all Kerberized machines, and especially the KDC, should be running the Network Time Protocol (NTP).

The **kerberos local-realm**, **kerberos realm**, and **kerberos server** commands are equivalent to the UNIX *krb.conf* file. Table 15 identifies mappings from the Cisco IOS configuration commands to a Kerberos 5 configuration file (*krb5.conf*).

Table 15 Kerberos 5 Configuration File and Commands

krb5.conf File	Cisco IOS Configuration Command
[libdefaults]	(in configuration mode)
default_realm = <i>DOMAIN.COM</i>	kerberos local-realm <i>DOMAIN.COM</i>
[domain_realm]	(in configuration mode)
.domain.com = <i>DOMAIN.COM</i> domain.com = <i>DOMAIN.COM</i>	kerberos realm <i>domain.com</i> <i>DOMAIN.COM</i> kerberos realm <i>domain.com</i> <i>DOMAIN.COM</i>
[realms]	(in configuration mode)
kdc = <i>DOMAIN.PIL.COM:750</i> admin_server = <i>DOMAIN.PIL.COM</i> default_domain = <i>DOMAIN.COM</i>	kerberos server <i>DOMAIN.COM</i> <i>172.65.44.2</i> (<i>172.65.44.2</i> is the example IP address for <i>DOMAIN.PIL.COM</i>)

For an example of defining a Kerberos realm, see the section “[Defining a Kerberos Realm](#)” later in this chapter.

Copying SRVTAB Files

To make it possible for remote users to authenticate to the router using Kerberos credentials, the router must share a secret key with the KDC. To do this, you must give the router a copy of the SRVTAB you extracted on the KDC.

The most secure method to copy SRVTAB files to the hosts in your Kerberos realm is to copy them onto physical media and go to each host in turn and manually copy the files onto the system. To copy SRVTAB files to the router, which does not have a physical media drive, you must transfer them via the network using TFTP.

To remotely copy SRVTAB files to the router from the KDC, use the following command in global configuration mode:

Command	Purpose
Router(config)# kerberos srvtab remote {hostname ip-address} {filename}	Retrieves an SRVTAB file from the KDC.

When you copy the SRVTAB file from the router to the KDC, the **kerberos srvtab remote** command parses the information in this file and stores it in the router's running configuration in the **kerberos srvtab entry** format. To ensure that the SRVTAB is available (does not need to be acquired from the KDC) when you reboot the router, use the **write memory** configuration command to write your running configuration (which contains the parsed SRVTAB file) to NVRAM.

For an example of copying SRVTAB files, see the section “[SRVTAB File Copying Example](#)” later in this chapter.

Specifying Kerberos Authentication

You have now configured Kerberos on your router. This makes it possible for the router to authenticate using Kerberos. The next step is to tell it to do so. Because Kerberos authentication is facilitated through AAA, you need to enter the **aaa authentication** command, specifying Kerberos as the authentication method. For more information, refer to the chapter “Configuring Authentication”.

Enabling Credentials Forwarding

With Kerberos configured thus far, a user authenticated to a Kerberized router has a TGT and can use it to authenticate to a host on the network. However, if the user tries to list credentials after authenticating to a host, the output will show no Kerberos credentials present.

You can optionally configure the router to forward users' TGTs with them as they authenticate from the router to Kerberized remote hosts on the network when using Kerberized Telnet, rcp, rsh, and rlogin (with the appropriate flags).

To force all clients to forward users' credentials as they connect to other hosts in the Kerberos realm, use the following command in global configuration mode:

Command	Purpose
Router(config)# kerberos credentials forward	Forces all clients to forward user credentials upon successful Kerberos authentication.

With credentials forwarding enabled, users' TGTs are automatically forwarded to the next host they authenticate to. In this way, users can connect to multiple hosts in the Kerberos realm without running the KINIT program each time to get a new TGT.

Opening a Telnet Session to the Router

To use Kerberos to authenticate users opening a Telnet session to the router from within the network, use the following command in global configuration mode:

Command	Purpose
Router(config)# aaa authentication login {default list-name} krb5_telnet	Sets login authentication to use the Kerberos 5 Telnet authentication protocol when using Telnet to connect to the router.

Although Telnet sessions to the router are authenticated, users must still enter a clear text password if they want to enter enable mode. The **kerberos instance map** command, discussed in a later section, allows them to authenticate to the router at a predefined privilege level.

Establishing an Encrypted Kerberized Telnet Session

Another way for users to open a secure Telnet session is to use Encrypted Kerberized Telnet. With Encrypted Kerberized Telnet, users are authenticated by their Kerberos credentials before a Telnet session is established. The Telnet session is encrypted using 56-bit Data Encryption Standard (DES) encryption with 64-bit Cipher Feedback (CFB). Because data sent or received is encrypted, not clear text, the integrity of the dialed router or access server can be more easily controlled.



Note

This feature is available only if you have the 56-bit encryption image. 56-bit DES encryption is subject to U.S. Government export control regulations.

To establish an encrypted Kerberized Telnet session from a router to a remote host, use either of the following commands in EXEC command mode:

Command	Purpose
Router(config)# connect host [port] /encrypt kerberos	Establishes an encrypted Telnet session.
or	
Router(config)# telnet host [port] /encrypt kerberos	

When a user opens a Telnet session from a Cisco router to a remote host, the router and remote host negotiate to authenticate the user using Kerberos credentials. If this authentication is successful, the router and remote host then negotiate whether or not to use encryption. If this negotiation is successful, both inbound and outbound traffic is encrypted using 56-bit DES encryption with 64-bit CFB.

When a user dials in from a remote host to a Cisco router configured for Kerberos authentication, the host and router will attempt to negotiate whether or not to use encryption for the Telnet session. If this negotiation is successful, the router will encrypt all outbound data during the Telnet session.

If encryption is not successfully negotiated, the session will be terminated and the user will receive a message stating that the encrypted Telnet session was not successfully established.

For information about enabling bidirectional encryption from a remote host, refer to the documentation specific to the remote host device.

For an example of using encrypted Kerberized Telnet to open a secure Telnet session, see the section [“Encrypted Telnet Session Example”](#) later in this chapter.

Enabling Mandatory Kerberos Authentication

As an added layer of security, you can optionally configure the router so that, after remote users authenticate to it, these users can authenticate to other services on the network only with Kerberized Telnet, rlogin, rsh, and rcp. If you do not make Kerberos authentication mandatory and Kerberos authentication fails, the application attempts to authenticate users using the default method of authentication for that network service; for example, Telnet and rlogin prompt for a password, and rsh attempts to authenticate using the local rhost file.

To make Kerberos authentication mandatory, use the following command in global configuration mode:

Command	Purpose
Router(config)# kerberos clients mandatory	Sets Telnet, rlogin, rsh, and rcp to fail if they cannot negotiate the Kerberos protocol with the remote server.

Enabling Kerberos Instance Mapping

As mentioned in the section “[Creating SRVTABs on the KDC](#),” you can create administrative instances of users in the KDC database. The **kerberos instance map** command allows you to map those instances to Cisco IOS privilege levels so that users can open secure Telnet sessions to the router at a predefined privilege level, obviating the need to enter a clear text password to enter enable mode.

To map a Kerberos instance to a Cisco IOS privilege level, use the following command in global configuration mode:

Command	Purpose
Router(config)# kerberos instance map <i>instance privilege-level</i>	Maps a Kerberos instance to a Cisco IOS privilege level.

If there is a Kerberos instance for user *loki* in the KDC database (for example, *loki/admin*), user *loki* can now open a Telnet session to the router as *loki/admin* and authenticate automatically at privilege level 15, assuming instance “admin” is mapped to privilege level 15. (See the section “[Adding Users to the KDC Database](#)” earlier in this chapter.)

Cisco IOS commands can be set to various privilege levels using the **privilege level** command.

After you map a Kerberos instance to a Cisco IOS privilege level, you must configure the router to check for Kerberos instances each time a user logs in. To run authorization to determine if a user is allowed to run an EXEC shell based on a mapped Kerberos instance, use the **aaa authorization** command with the **krb5-instance** keyword. For more information, refer to the chapter “Configuring Authorization.”

Monitoring and Maintaining Kerberos

To display or remove a current user's credentials, use the following commands in EXEC mode:

	Command	Purpose
Step 1	Router# show kerberos creds	Lists the credentials in a current user's credentials cache.
Step 2	Router# clear kerberos creds	Destroys all credentials in a current user's credentials cache, including those forwarded.

For an example of Kerberos configuration, see the section “[Kerberos Configuration Examples](#)”.

Kerberos Configuration Examples

The following sections provide Kerberos configuration examples:

- [Kerberos Realm Definition Examples](#)
- [SRVTAB File Copying Example](#)
- [Kerberos Configuration Examples](#)
- [Encrypted Telnet Session Example](#)

Kerberos Realm Definition Examples

To define CISCO.COM as the default Kerberos realm, use the following command:

```
kerberos local-realm CISCO.COM
```

To tell the router that the CISCO.COM KDC is running on host 10.2.3.4 at port number 170, use the following Kerberos command:

```
kerberos server CISCO.COM 10.2.3.4 170
```

To map the DNS domain cisco.com to the Kerberos realm CISCO.COM, use the following command:

```
kerberos realm.cisco.com CISCO.COM
```

SRVTAB File Copying Example

To copy over the SRVTAB file on a host named host123.cisco.com for a router named router1.cisco.com, the command would look like this:

```
kerberos srvtab remote host123.cisco.com router1.cisco.com-new-srvtab
```

Kerberos Configuration Examples

This section provides a typical non-Kerberos router configuration and shows output for this configuration from the **write term** command, then builds on this configuration by adding optional Kerberos functionality. Output for each configuration is presented for comparison against the previous configuration.

This example shows how to use the `kdb5_edit` program to perform the following configuration tasks:

- Adding user `chet` to the Kerberos database
- Adding a privileged Kerberos instance of user `chet` (`chet/admin`) to the Kerberos database
- Adding a restricted instance of `chet` (`chet/restricted`) to the Kerberos database
- Adding workstation `chet-ss20.cisco.com`
- Adding router `chet-2500.cisco.com` to the Kerberos database
- Adding workstation `chet-ss20.cisco.com` to the Kerberos database
- Extracting SRVTABs for the router and workstations
- Listing the contents of the KDC database (with the `ldb` command)

Note that, in this sample configuration, host `chet-ss20` is also the KDC:

```
chet-ss20# sbin/kdb5_edit
kdb5_edit: ank chet
Enter password:
Re-enter password for verification:
kdb5_edit: ank chet/admin
Enter password:
Re-enter password for verification:
kdb5_edit: ank chet/restricted
Enter password:
Re-enter password for verification:
kdb5_edit: ark host/chet-ss20.cisco.com
kdb5_edit: ark host/chet-2500.cisco.com
kdb5_edit: xst chet-ss20.cisco.com host
'host/chet-ss20.cisco.com@CISCO.COM' added to keytab
'WRFILE:chet-ss20.cisco.com-new-srvtab'
kdb5_edit: xst chet-2500.cisco.com host
'host/chet-2500.cisco.com@CISCO.COM' added to keytab
'WRFILE:chet-2500.cisco.com-new-srvtab'
kdb5_edit: ldb
entry: host/chet-2500.cisco.com@CISCO.COM
entry: chet/restricted@CISCO.COM
entry: chet@CISCO.COM
entry: K/M@CISCO.COM
entry: host/chet-ss20.cisco.com@CISCO.COM
entry: krbtgt/CISCO.COM@CISCO.COM
entry: chet/admin@CISCO.COM
kdb5_edit: q
chet-ss20#
```

The following example shows output from a **write term** command, which displays the configuration of router `chet-2500`. This is a typical configuration with no Kerberos authentication.

```
chet-2500# write term
Building configuration...

Current configuration:
!
! Last configuration
change at 14:03:55 PDT Mon May 13 1996
!
version 11.2
service udp-small-servers
service tcp-small-servers
!
hostname chet-2500
!
clock timezone PST -8
```

```

clock summer-time PDT recurring
aaa new-model
aaa authentication login console none
aaa authentication ppp local local
enable password sMudgKin
!
username chet-2500 password 7 sMudgkin
username chet-3000 password 7 sMudgkin
username chetin password 7 sMudgkin
!
interface Ethernet0
 ip address 172.16.0.0 255.255.255.0
!
interface Serial0
 no ip address
 shutdown
 no fair-queue
!
interface Serial1
 no ip address
 shutdown
 no fair-queue
!
interface Async2
 ip unnumbered Ethernet0
 encapsulation ppp
 shutdown
 async dynamic routing
 async mode dedicated
 no cdp enable
 ppp authentication pap local
 no tarp propagate
!
interface Async3
 ip unnumbered Ethernet0
 encapsulation ppp
 shutdown
 async dynamic address
 async dynamic routing
 async mode dedicated
 no cdp enable
 ppp authentication pap local
 no tarp propagate
!
router eigrp 109
 network 172.17.0.0
 no auto-summary
!
ip default-gateway 172.30.55.64
ip domain-name cisco.com
ip name-server 192.168.0.0
ip classless
!
!

line con 0
 exec-timeout 0 0
 login authentication console
line 1 16
 transport input all
line aux 0
 transport input all
line vty 0 4
 password sMudgKin

```

```

!
ntp clock-period 17179703
ntp peer 172.19.10.0
ntp peer 172.19.0.0
end

```

The following example shows how to enable user authentication on the router via the Kerberos database. To enable user authentication via the Kerberos database, you would perform the following tasks:

- Entering configuration mode
- Defining the Kerberos local realm
- Identifying the machine hosting the KDC
- Enabling credentials forwarding
- Specifying Kerberos as the method of authentication for login
- Exiting configuration mode (CTL-Z)
- Writing the new configuration to the terminal

```

chet-2500# configure term
Enter configuration commands, one per line. End with CNTL/Z.
chet-2500(config)# kerberos local-realm CISCO.COM
chet-2500(config)# kerberos server CISCO.COM chet-ss20
Translating "chet-ss20"...domain server (192.168.0.0) [OK]

chet-2500(config)# kerberos credentials forward
chet-2500(config)# aaa authentication login default krb5
chet-2500(config)#
chet-2500#
%SYS-5-CONFIG_I: Configured from console by console
chet-2500# write term

```

Compare the following configuration with the previous one. In particular, look at the lines beginning with the words “aaa,” “username,” and “kerberos” (lines 10 through 20) in this new configuration.

Building configuration...

Current configuration:

```

!
! Last configuration change at 14:05:54 PDT Mon May 13 1996
!
version 11.2
service udp-small-servers
service tcp-small-servers
!
hostname chet-2500
!
clock timezone PST -8
clock summer-time PDT recurring
aaa new-model
aaa authentication login default krb5
aaa authentication login console none
aaa authentication ppp local local
enable password sMudgKin
!
username chet-2500 password 7 sMudgkin
username chet-3000 password 7 sMudgkin
username chetin password 7 sMudgkin
kerberos local-realm CISCO.COM
kerberos server CISCO.COM 172.71.54.14
kerberos credentials forward
!

```

```

interface Ethernet0
 ip address 172.16.0.0 255.255.255.0
!
interface Serial0
 no ip address
 shutdown
 no fair-queue
!
interface Serial1
 no ip address
 shutdown
 no fair-queue
!
interface Async2
 ip unnumbered Ethernet0
 encapsulation ppp
 shutdown
 async dynamic routing
 async mode dedicated
 no cdp enable
 ppp authentication pap local
 no tarp propagate
!
interface Async3
 ip unnumbered Ethernet0
 encapsulation ppp
 shutdown
 async dynamic address
 async dynamic routing
 async mode dedicated
 no cdp enable
 ppp authentication pap local
 no tarp propagate
!
router eigrp 109
 network 172.17.0.0
 no auto-summary
!
ip default-gateway 172.30.55.64
ip domain-name cisco.com
ip name-server 192.168.0.0
ip classless
!
!
line con 0
 exec-timeout 0 0
 login authentication console
line 1 16
 transport input all
line aux 0
 transport input all
line vty 0 4
 password sMudgKin
!
ntp clock-period 17179703
ntp peer 172.19.10.0
ntp peer 172.19.0.0
end

```

With the router configured thus far, user chet can log in to the router with a username and password and automatically obtain a TGT, as illustrated in the next example. With possession of a credential, user chet successfully authenticates to host chet-ss20 without entering a username/password.

```
chet-ss20% telnet chet-2500
Trying 172.16.0.0 ...
Connected to chet-2500.cisco.com.
Escape character is '^'].
```

User Access Verification

```
Username: chet
Password:
```

```
chet-2500> show kerberos creds
Default Principal: chet@CISCO.COM
Valid Starting      Expires      Service Principal
13-May-1996 14:05:39 13-May-1996 22:06:40 krbtgt/CISCO.COM@CISCO.COM
```

```
chet-2500> telnet chet-ss20
Trying chet-ss20.cisco.com (172.71.54.14)... Open
Kerberos:      Successfully forwarded credentials
```

SunOS UNIX (chet-ss20) (pts/7)

```
Last login: Mon May 13 13:47:35 from chet-ss20.cisco.c
Sun Microsystems Inc.  SunOS 5.4      Generic July 1994
unknown mode: new
chet-ss20%
```

The following example shows how to authenticate to the router using Kerberos credentials. To authenticate using Kerberos credentials, you would perform the following tasks:

- Entering configuration mode
- Remotely copying over the SRVTAB file from the KDC
- Setting authentication at login to use the Kerberos 5 Telnet authentication protocol when using Telnet to connect to the router
- Writing the configuration to the terminal

Note that the new configuration contains a **kerberos srvtab entry** line. This line is created by the **kerberos srvtab remote** command.

```
chet-2500# configure term
Enter configuration commands, one per line. End with CNTL/Z.
chet-2500(config)# kerberos srvtab remote earth chet/chet-2500.cisco.com-new-srvtab
Translating "earth"...domain server (192.168.0.0) [OK]
```

```
Loading chet/chet-2500.cisco.com-new-srvtab from 172.68.1.123 (via Ethernet0): !
[OK - 66/1000 bytes]
```

```
chet-2500(config)# aaa authentication login default krb5-telnet krb5
chet-2500(config)#
chet-2500#
%SYS-5-CONFIG_I: Configured from console by console
chet-2500# write term
Building configuration...
```

```
Current configuration:
!
```

```

! Last configuration change at 14:08:32 PDT Mon May 13 1996
!
version 11.2
service udp-small-servers
service tcp-small-servers
!
hostname chet-2500
!
clock timezone PST -8
clock summer-time PDT recurring
aaa new-model
aaa authentication login default krb5-telnet krb5
aaa authentication login console none
aaa authentication ppp local local
enable password sMudgKin
!
username chet-2500 password 7 sMudgkin
username chet-3000 password 7 sMudgkin
username chetin password 7 sMudgkin
kerberos local-realm CISCO.COM
kerberos srvtab entry host/chet-2500.cisco.com@CISCO.COM 0 832015393 1 1 8 7 sMudgkin
kerberos server CISCO.COM 172.71.54.14
kerberos credentials forward
!
interface Ethernet0
 ip address 172.16.0.0 255.255.255.0
!
interface Serial0
 no ip address
 shutdown
 no fair-queue
!

interface Serial1
 no ip address
 shutdown
 no fair-queue
!
interface Async2
 ip unnumbered Ethernet0
 encapsulation ppp
 shutdown
 async dynamic routing
 async mode dedicated
 no cdp enable
 ppp authentication pap local
 no tarp propagate
!
interface Async3
 ip unnumbered Ethernet0
 encapsulation ppp
 shutdown
 async dynamic address
 async dynamic routing
 async mode dedicated
 no cdp enable
 ppp authentication pap local
 no tarp propagate
!
router eigrp 109
 network 172.17.0.0
 no auto-summary
!
ip default-gateway 172.30.55.64

```



```

ip domain-name cisco.com
ip name-server 192.168.0.0
ip classless
!
!
line con 0
  exec-timeout 0 0
  login authentication console
line 1 16
  transport input all
line aux 0
  transport input all
line vty 0 4
  password sMudgKin
!
ntp clock-period 17179703
ntp peer 172.19.10.0
ntp peer 172.19.0.0
end

chet-2500#

```

With this configuration, the user can Telnet in to the router using Kerberos credentials, as illustrated in the next example:

```

chet-ss20% bin/telnet -a -F chet-2500
Trying 172.16.0.0...
Connected to chet-2500.cisco.com.
Escape character is '^'.
[ Kerberos V5 accepts you as "chet@CISCO.COM" ]

User Access Verification

chet-2500>[ Kerberos V5 accepted forwarded credentials ]

chet-2500> show kerberos creds
Default Principal:  chet@CISCO.COM
Valid Starting      Expires              Service Principal
13-May-1996 15:06:25  14-May-1996 00:08:29  krbtgt/CISCO.COM@CISCO.COM

chet-2500>q
Connection closed by foreign host.
chet-ss20%

```

The following example shows how to map Kerberos instances to Cisco's privilege levels. To map Kerberos instances to privilege levels, you would perform the following tasks:

- Entering configuration mode
- Mapping the Kerberos instance admin to privilege level 15
- Mapping the Kerberos instance restricted to privilege level 3
- Specifying that the instance defined by the **kerberos instance map** command be used for AAA Authorization
- Writing the configuration to the terminal

```

chet-2500# configure term
Enter configuration commands, one per line. End with CNTL/Z.
chet-2500(config)# kerberos instance map admin 15
chet-2500(config)# kerberos instance map restricted 3
chet-2500(config)# aaa authorization exec default krb5-instance
chet-2500(config)#
chet-2500#

```

```

%SYS-5-CONFIG_I: Configured from console by console
chet-2500# write term
Building configuration...

Current configuration:
!
! Last configuration change at 14:59:05 PDT Mon May 13 1996
!
version 11.2
service udp-small-servers
service tcp-small-servers
!
hostname chet-2500
!
aaa new-model
aaa authentication login default krb5-telnet krb5
aaa authentication login console none
aaa authentication ppp default krb5 local
aaa authorization exec default krb5-instance
enable password sMudgKin
!
username chet-2500 password 7 sMudgkin
username chet-3000 password 7 sMudgkin
username chetin password 7 sMudgkin
ip domain-name cisco.com
ip name-server 192.168.0.0
kerberos local-realm CISCO.COM
kerberos srvtab entry host/chet-2500.cisco.com@CISCO.COM 0 832015393 1 1 8 7 sMudgkin
kerberos server CISCO.COM 172.71.54.14
kerberos instance map admin 15
kerberos instance map restricted 3
kerberos credentials forward
clock timezone PST -8
clock summer-time PDT recurring
!
interface Ethernet0
 ip address 172.16.0.0 255.255.255.0
!
interface Serial0
 no ip address
 shutdown
 no fair-queue
!
interface Serial1
 no ip address
 shutdown
 no fair-queue
!
interface Async2
 ip unnumbered Ethernet0
 encapsulation ppp
 shutdown
 async dynamic routing
 async mode dedicated
 no cdp enable
 ppp authentication pap local
 no tarp propagate
!
interface Async3
 ip unnumbered Ethernet0
 encapsulation ppp
 shutdown
 async dynamic address
 async dynamic routing

```

```

    async mode dedicated
    no cdp enable
    ppp authentication pap local
    no tarp propagate
    !
router eigrp 109
  network 172.17.0.0
  no auto-summary
  !
ip default-gateway 172.30.55.64
ip classless
  !
  !
line con 0
  exec-timeout 0 0
  login authentication console
line 1 16
  transport input all
line aux 0
  transport input all
line vty 0 4
  password sMudgKin
  !
ntp clock-period 17179703
ntp peer 172.19.10.0
ntp peer 172.19.0.0
end

chet-2500#

```

The following example shows output from the three types of sessions now possible for user chet with Kerberos instances turned on:

```

chet-ss20% telnet chet-2500
Trying 172.16.0.0 ...
Connected to chet-2500.cisco.com.
Escape character is '^]'.

User Access Verification

Username: chet
Password:

chet-2500> show kerberos creds
Default Principal: chet@CISCO.COM
Valid Starting      Expires      Service Principal
13-May-1996 14:58:28 13-May-1996 22:59:29 krbtgt/CISCO.COM@CISCO.COM

chet-2500> show privilege
Current privilege level is 1
chet-2500> q
Connection closed by foreign host.
chet-ss20% telnet chet-2500
Trying 172.16.0.0 ...
Connected to chet-2500.cisco.com.
Escape character is '^]'.

User Access Verification

Username: chet/admin
Password:

chet-2500# show kerberos creds

```

```

Default Principal: chet/admin@CISCO.COM
Valid Starting      Expires      Service Principal
13-May-1996 14:59:44    13-May-1996 23:00:45    krbtgt/CISCO.COM@CISCO.COM
chet-2500# show privilege
Current privilege level is 15
chet-2500# q
Connection closed by foreign host.
chet-ss20% telnet chet-2500
Trying 172.16.0.0 ...
Connected to chet-2500.cisco.com.
Escape character is '^]'.

User Access Verification

Username: chet/restricted
Password:

chet-2500# show kerberos creds
Default Principal: chet/restricted@CISCO.COM
Valid Starting      Expires      Service Principal
13-May-1996 15:00:32    13-May-1996 23:01:33    krbtgt/CISCO.COM@CISCO.COM

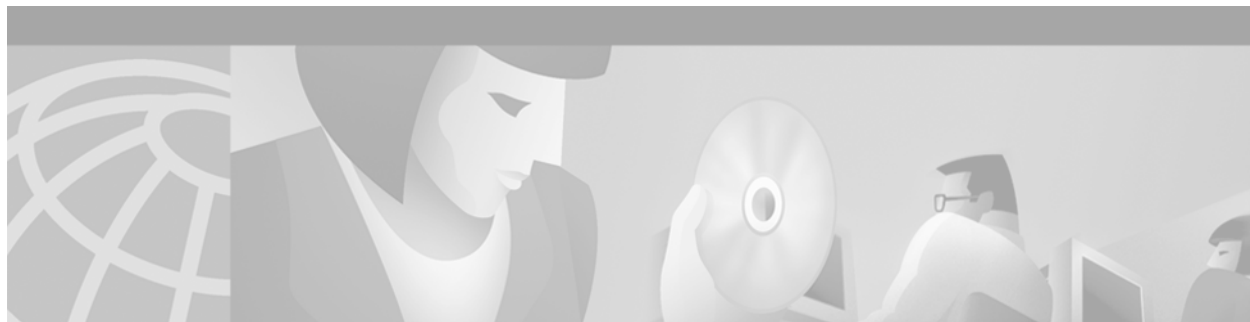
chet-2500# show privilege
Current privilege level is 3
chet-2500# q
Connection closed by foreign host.
chet-ss20%

```

Encrypted Telnet Session Example

The following example shows how to establish an encrypted Telnet session from a router to a remote host named “host1”:

```
Router> telnet host1 /encrypt kerberos
```



Access Control Lists: Overview and Guidelines

Cisco provides basic traffic filtering capabilities with access control lists (also referred to as *access lists*). Access lists can be configured for all routed network protocols (IP, AppleTalk, and so on) to filter the packets of those protocols as the packets pass through a router.

You can configure access lists at your router to control access to a network: access lists can prevent certain traffic from entering or exiting a network.

In This Chapter

This chapter describes access lists as part of a security solution. This chapter includes tips, cautions, considerations, recommendations, and general guidelines for how to use access lists.

This chapter has these sections:

- [About Access Control Lists](#)
- [Overview of Access List Configuration](#)
- [Finding Complete Configuration and Command Information for Access Lists](#)

About Access Control Lists

This section briefly describes what access lists do; why and when you should configure access lists; and basic versus advanced access lists.

This section has the following sections:

- [What Access Lists Do](#)
- [Why You Should Configure Access Lists](#)
- [When to Configure Access Lists](#)
- [Basic Versus Advanced Access Lists](#)

What Access Lists Do

Access lists filter network traffic by controlling whether routed packets are forwarded or blocked at the router's interfaces. Your router examines each packet to determine whether to forward or drop the packet, on the basis of the criteria you specified within the access lists.

Access list criteria could be the source address of the traffic, the destination address of the traffic, the upper-layer protocol, or other information. Note that sophisticated users can sometimes successfully evade or fool basic access lists because no authentication is required.

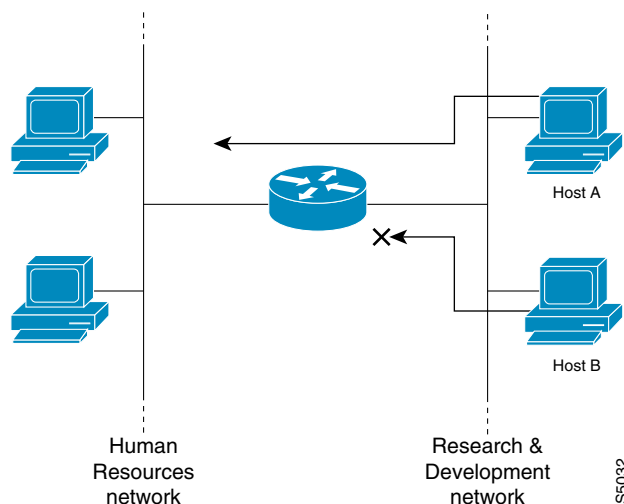
Why You Should Configure Access Lists

There are many reasons to configure access lists; for example, you can use access lists to restrict contents of routing updates or to provide traffic flow control. One of the most important reasons to configure access lists is to provide security for your network, which is the focus of this chapter.

You should use access lists to provide a basic level of security for accessing your network. If you do not configure access lists on your router, all packets passing through the router could be allowed onto all parts of your network.

Access lists can allow one host to access a part of your network and prevent another host from accessing the same area. In [Figure 14](#), host A is allowed to access the Human Resources network, and host B is prevented from accessing the Human Resources network.

Figure 14 Using Traffic Filters to Prevent Traffic from Being Routed to a Network



You can also use access lists to decide which types of traffic are forwarded or blocked at the router interfaces. For example, you can permit e-mail traffic to be routed, but at the same time block all Telnet traffic.

When to Configure Access Lists

Access lists should be used in “firewall” routers, which are often positioned between your internal network and an external network such as the Internet. You can also use access lists on a router positioned between two parts of your network, to control traffic entering or exiting a specific part of your internal network.

To provide the security benefits of access lists, you should at a minimum configure access lists on border routers—routers situated at the edges of your networks. This provides a basic buffer from the outside network, or from a less controlled area of your own network into a more sensitive area of your network.

On these routers, you should configure access lists for each network protocol configured on the router interfaces. You can configure access lists so that inbound traffic or outbound traffic or both are filtered on an interface.

Access lists must be defined on a per-protocol basis. In other words, you should define access lists for every protocol enabled on an interface if you want to control traffic flow for that protocol.

**Note**

Some protocols refer to access lists as *filters*.

Basic Versus Advanced Access Lists

This chapter describes how to use standard and static extended access lists, which are the basic types of access lists. Some type of basic access list should be used with each routed protocol that you have configured for router interfaces.

Besides the basic types of access lists described in this chapter, there are also more advanced access lists available, which provide additional security features and give you greater control over packet transmission. These advanced access lists and features are described in the other chapters within the part “Traffic Filtering and Firewalls.”

Overview of Access List Configuration

Each protocol has its own set of specific tasks and rules that are required in order for you to provide traffic filtering. In general, most protocols require at least two basic steps to be accomplished. The first step is to create an access list definition, and the second step is to apply the access list to an interface.

The following sections describe these two steps:

- [Creating Access Lists](#)
- [Applying Access Lists to Interfaces](#)

Note that some protocols refer to access lists as *filters* and refer to the act of applying the access lists to interfaces as *filtering*.

Creating Access Lists

Create access lists for each protocol you wish to filter, per router interface. For some protocols, you create one access list to filter inbound traffic, and one access list to filter outbound traffic.

To create an access list, you specify the protocol to filter, you assign a unique name or number to the access list, and you define packet filtering criteria. A single access list can have multiple filtering criteria statements.

Cisco recommends that you create your access lists on a TFTP server and then download the access lists to your router. This approach can considerably simplify maintenance of your access lists. For details, see the “[Creating and Editing Access List Statements on a TFTP Server](#)” section later in this chapter.

The protocols for which you can configure access lists are identified in [Table 16](#).

This section has the following sections:

- [Assigning a Unique Name or Number to Each Access List](#)
- [Defining Criteria for Forwarding or Blocking Packets](#)
- [Creating and Editing Access List Statements on a TFTP Server](#)

Assigning a Unique Name or Number to Each Access List

When configuring access lists on a router, you must identify each access list uniquely within a protocol by assigning either a name or a number to the protocol's access list.



Note

Access lists of some protocols must be identified by a name, and access lists of other protocols must be identified by a number. Some protocols can be identified by either a name or a number. When a number is used to identify an access list, the number must be within the specific range of numbers that is valid for the protocol.

You can specify access lists by names for the following protocols:

- Apollo Domain
- IP
- IPX
- ISO CLNS
- NetBIOS IPX
- Source-route bridging NetBIOS

You can specify access lists by numbers for the protocols listed in [Table 16](#). [Table 16](#) also lists the range of access list numbers that is valid for each protocol.

Table 16 *Protocols with Access Lists Specified by Numbers*

Protocol	Range
IP	1–99, 1300–1999
Extended IP	100–199, 2000–2699
Ethernet type code	200–299
Ethernet address	700–799
Transparent bridging (protocol type)	200–299
Transparent bridging (vendor code)	700–799
Extended transparent bridging	1100–1199
DECnet and extended DECnet	300–399
XNS	400–499
Extended XNS	500–599
AppleTalk	600–699
Source-route bridging (protocol type)	200–299
Source-route bridging (vendor code)	700–799

Table 16 Protocols with Access Lists Specified by Numbers (continued)

Protocol	Range
IPX	800–899
Extended IPX	900–999
IPX SAP	1000–1099
Standard VINES	1–100
Extended VINES	101–200
Simple VINES	201–300

Defining Criteria for Forwarding or Blocking Packets

When creating an access list, you define criteria that are applied to each packet that is processed by the router; the router decides whether to forward or block each packet on the basis of whether or not the packet matches the criteria.

Typical criteria you define in access lists are packet source addresses, packet destination addresses, and upper-layer protocol of the packet. However, each protocol has its own specific set of criteria that can be defined.

For a single access list, you can define multiple criteria in multiple, separate access list statements. Each of these statements should reference the same identifying name or number, to tie the statements to the same access list. You can have as many criteria statements as you want, limited only by the available memory. Of course, the more statements you have, the more difficult it will be to comprehend and manage your access lists.

The Implied “Deny All Traffic” Criteria Statement

At the end of every access list is an implied “deny all traffic” criteria statement. Therefore, if a packet does not match any of your criteria statements, the packet will be blocked.

**Note**

For most protocols, if you define an inbound access list for traffic filtering, you should include explicit access list criteria statements to permit routing updates. If you do not, you might effectively lose communication from the interface when routing updates are blocked by the implicit “deny all traffic” statement at the end of the access list.

The Order in Which You Enter Criteria Statements

Note that each additional criteria statement that you enter is appended to the *end* of the access list statements. Also note that you cannot delete individual statements after they have been created. You can only delete an entire access list.

The order of access list statements is important! When the router is deciding whether to forward or block a packet, the Cisco IOS software tests the packet against each criteria statement in the order in which the statements were created. After a match is found, no more criteria statements are checked.

If you create a criteria statement that explicitly permits all traffic, no statements added later will ever be checked. If you need additional statements, you must delete the access list and retype it with the new entries.

Creating and Editing Access List Statements on a TFTP Server

Because the order of access list criteria statements is important, and because you cannot reorder or delete criteria statements on your router, Cisco recommends that you create all access list statements on a TFTP server, and then download the entire access list to your router.

To use a TFTP server, create the access list statements using any text editor, and save the access list in ASCII format to a TFTP server that is accessible by your router. Then, from your router, use the **copy tftp:file_id system:running-config** command to copy the access list to your router. Finally, perform the **copy system:running-config nvram:startup-config** command to save the access list to your router's NVRAM.

Then, if you ever want to make changes to an access list, you can make them to the text file on the TFTP server, and copy the edited file to your router as before.

**Note**

The first command of an edited access list file should delete the previous access list (for example, type a **no access-list** command at the beginning of the file). If you do not first delete the previous version of the access list, when you copy the edited file to your router you will merely be appending additional criteria statements to the end of the existing access list.

Applying Access Lists to Interfaces

For some protocols, you can apply up to two access lists to an interface: one inbound access list and one outbound access list. With other protocols, you apply only one access list which checks both inbound and outbound packets.

If the access list is inbound, when the router receives a packet, the Cisco IOS software checks the access list's criteria statements for a match. If the packet is permitted, the software continues to process the packet. If the packet is denied, the software discards the packet.

If the access list is outbound, after receiving and routing a packet to the outbound interface, the software checks the access list's criteria statements for a match. If the packet is permitted, the software transmits the packet. If the packet is denied, the software discards the packet.

**Note**

Access lists that are applied to interfaces do not filter traffic that originates from that router.

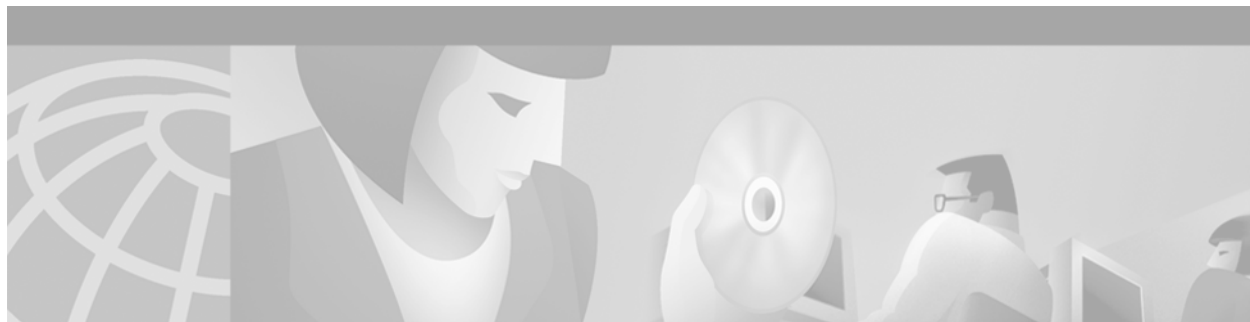
Finding Complete Configuration and Command Information for Access Lists

The guidelines discussed in this chapter apply in general to all protocols. The specific instructions for creating access lists and applying them to interfaces vary from protocol to protocol, and this specific information is not included in this chapter.

To find complete configuration and command information to configure access lists for a specific protocol, see the corresponding chapters in the Cisco IOS configuration guides and command references. For example, to configure access lists for the IP protocol, refer to the section "Filtering IP Packets Using Access Lists" in the ["Configuring IP Services"](#) chapter of the *Cisco IOS IP Configuration Guide*, Release 12.2.

For information on dynamic access lists, see the chapter "Configuring Lock-and-Key Security (Dynamic Access Lists)" later in this book.

For information on reflexive access lists, see the chapter "Configuring IP Session Filtering (Reflexive Access Lists)" later in this book.



Configuring Lock-and-Key Security (Dynamic Access Lists)

This chapter describes how to configure lock-and-key security at your router. Lock-and-key is a traffic filtering security feature available for the IP protocol.

For a complete description of lock-and-key commands, refer to the “Lock-and-Key Commands” chapter of the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the chapter “Identifying Supported Platforms” section in the “Using Cisco IOS Software.”

In This Chapter

This chapter has the following sections:

- [About Lock-and-Key](#)
- [Compatibility with Releases Before Cisco IOS Release 11.1](#)
- [Risk of Spoofing with Lock-and-Key](#)
- [Router Performance Impacts with Lock-and-Key](#)
- [Prerequisites to Configuring Lock-and-Key](#)
- [Configuring Lock-and-Key](#)
- [Verifying Lock-and-Key Configuration](#)
- [Maintaining Lock-and-Key](#)
- [Lock-and-Key Configuration Examples](#)

About Lock-and-Key

Lock-and-key is a traffic filtering security feature that dynamically filters IP protocol traffic. Lock-and-key is configured using IP dynamic extended access lists. Lock-and-key can be used in conjunction with other standard access lists and static extended access lists.

When lock-and-key is configured, designated users whose IP traffic is normally blocked at a router can gain temporary access through the router. When triggered, lock-and-key reconfigures the interface's existing IP access list to permit designated users to reach their designated host(s). Afterwards, lock-and-key reconfigures the interface back to its original state.

For a user to gain access to a host through a router with lock-and-key configured, the user must first open a Telnet session to the router. When a user initiates a standard Telnet session to the router, lock-and-key automatically attempts to authenticate the user. If the user is authenticated, they will then gain temporary access through the router and be able to reach their destination host.

This section has the following sections:

- [Benefits of Lock-and-Key](#)
- [When to Use Lock-and-Key](#)
- [How Lock-and-Key Works](#)

Benefits of Lock-and-Key

Lock-and-key provides the same benefits as standard and static extended access lists (these benefits are discussed in the chapter “Access Control Lists: Overview and Guidelines”). However, lock-and-key also has the following security benefits over standard and static extended access lists:

- Lock-and-key uses a challenge mechanism to authenticate individual users.
- Lock-and-key provides simpler management in large internetworks.
- In many cases, lock-and-key reduces the amount of router processing required for access lists.
- Lock-and-key reduces the opportunity for network break-ins by network hackers.

With lock-and-key, you can specify which users are permitted access to which source and destination hosts. These users must pass a user authentication process before they are permitted access to their designated hosts. Lock-and-key creates dynamic user access through a firewall, without compromising other configured security restrictions.

When to Use Lock-and-Key

Two examples of when you might use lock-and-key follow:

- When you want a specific remote user (or group of remote users) to be able to access a host within your network, connecting from their remote hosts via the Internet. Lock-and-key authenticates the user, then permits limited access through your firewall router for the individual's host or subnet, for a finite period of time.
- When you want a subset of hosts on a local network to access a host on a remote network protected by a firewall. With lock-and-key, you can enable access to the remote host only for the desired set of local user's hosts. Lock-and-key require the users to authenticate through a TACACS+ server, or other security server, before allowing their hosts to access the remote hosts.

How Lock-and-Key Works

The following process describes the lock-and-key access operation:

1. A user opens a Telnet session to a border (firewall) router configured for lock-and-key. The user connects via the virtual terminal port on the router.
2. The Cisco IOS software receives the Telnet packet, opens a Telnet session, prompts for a password, and performs a user authentication process. The user must pass authentication before access through the router is allowed. The authentication process can be done by the router or by a central access security server such as a TACACS+ or RADIUS server.
3. When the user passes authentication, they are logged out of the Telnet session, and the software creates a temporary entry in the dynamic access list. (Per your configuration, this temporary entry can limit the range of networks to which the user is given temporary access.)
4. The user exchanges data through the firewall.
5. The software deletes the temporary access list entry when a configured timeout is reached, or when the system administrator manually clears it. The configured timeout can either be an idle timeout or an absolute timeout.



Note

The temporary access list entry is not automatically deleted when the user terminates a session. The temporary access list entry remains until a configured timeout is reached or until it is cleared by the system administrator.

Compatibility with Releases Before Cisco IOS Release 11.1

Enhancements to the **access-list** command are used for lock-and-key. These enhancements are backward compatible—if you migrate from a release before Cisco IOS Release 11.1 to a newer release, your access lists will be automatically converted to reflect the enhancements. However, if you try to use lock-and-key with a release before Cisco IOS Release 11.1, you might encounter problems as described in the following caution paragraph:



Caution

Cisco IOS releases before Release 11.1 are not upwardly compatible with the lock-and-key access list enhancements. Therefore, if you save an access list with software older than Release 11.1, and then use this software, the resulting access list will not be interpreted correctly. *This could cause you severe security problems.* You must save your old configuration files with Cisco IOS Release 11.1 or later software before booting an image with these files.

Risk of Spoofing with Lock-and-Key

**Caution**

Lock-and-key access allows an external event (a Telnet session) to place an opening in the firewall. While this opening exists, the router is susceptible to source address spoofing.

When lock-and-key is triggered, it creates a dynamic opening in the firewall by temporarily reconfiguring an interface to allow user access. While this opening exists, another host might spoof the authenticated user's address to gain access behind the firewall. Lock-and-key does not cause the address spoofing problem; the problem is only identified here as a concern to the user. Spoofing is a problem inherent to all access lists, and lock-and-key does not specifically address this problem.

To prevent spoofing, configure encryption so that traffic from the remote host is encrypted at a secured remote router, and decrypted locally at the router interface providing lock-and-key. You want to ensure that all traffic using lock-and-key will be encrypted when entering the router; this way no hackers can spoof the source address, because they will be unable to duplicate the encryption or to be authenticated as is a required part of the encryption setup process.

Router Performance Impacts with Lock-and-Key

When lock-and-key is configured, router performance can be affected in the following ways:

- When lock-and-key is triggered, the dynamic access list forces an access list rebuild on the silicon switching engine (SSE). This causes the SSE switching path to slow down momentarily.
- Dynamic access lists require the idle timeout facility (even if the timeout is left to default) and therefore cannot be SSE switched. These entries must be handled in the protocol fast-switching path.
- When remote users trigger lock-and-key at a border router, additional access list entries are created on the border router interface. The interface's access list will grow and shrink dynamically. Entries are dynamically removed from the list after either the idle-timeout or max-timeout period expires. Large access lists can degrade packet switching performance, so if you notice performance problems, you should look at the border router configuration to see if you should remove temporary access list entries generated by lock-and-key.

Prerequisites to Configuring Lock-and-Key

Lock-and-key uses IP extended access lists. You must have a solid understanding of how access lists are used to filter traffic, before you attempt to configure lock-and-key. Access lists are described in the chapter "Access Control Lists: Overview and Guidelines."

Lock-and-key employs user authentication and authorization as implemented in Cisco's authentication, authorization, and accounting (AAA) paradigm. You must understand how to configure AAA user authentication and authorization before you configure lock-and-key. User authentication and authorization is explained in the "Authentication, Authorization, and Accounting (AAA)" part of this document.

Lock-and-key uses the **autocommand** command, which you should understand. This command is described in the "Modem Support and Asynchronous Device Commands" chapter of the *Cisco IOS Dial Technologies Command Reference*.

Configuring Lock-and-Key

To configure lock-and-key, use the following commands beginning in global configuration mode. While completing these steps, be sure to follow the guidelines listed in the “[Lock-and-Key Configuration Guidelines](#)” section of this chapter.

	Command	Purpose
Step 1	Router(config)# access-list <i>access-list-number</i> [dynamic <i>dynamic-name</i> [timeout <i>minutes</i>]] { deny permit } telnet <i>source source-wildcard destination destination-wildcard</i> [precedence <i>precedence</i>] [tos <i>tos</i>] [established] [log]	Configures a dynamic access list, which serves as a template and placeholder for temporary access list entries.
Step 2	Router(config)# access-list dynamic-extend	(Optional) Extends the absolute timer of the dynamic ACL by six minutes when you open another Telnet session into the router to re-authenticate yourself using lock-and-key. Use this command if your job will run past the ACL’s absolute timer.
Step 3	Router(config)# interface <i>type number</i>	Configures an interface and enters interface configuration mode.
Step 4	Router(config-if)# ip access-group <i>access-list-number</i>	Applies the access list to the interface.
Step 5	Router(config-if)# exit	Exits interface configuration mode and enters global configuration mode.
Step 6	Router(config)# line vty <i>line-number</i> [<i>ending-line-number</i>]	Defines one or more virtual terminal (VTY) ports and enters line configuration mode. If you specify multiple VTY ports, they must all be configured identically because the software hunts for available VTY ports on a round-robin basis. If you do not want to configure all your VTY ports for lock-and-key access, you can specify a group of VTY ports for lock-and-key support only.
Step 7	Router(config-line)# login tacacs or Router(config-line)# password <i>password</i> or Router(config-line)# login local or Router(config-line)# exit then Router(config)# username <i>name</i> password <i>secret</i>	Configures user authentication in line or global configuration mode.
Step 8	Router(config-line)# autocommand access-enable [host] [timeout <i>minutes</i>] or Router(config)# autocommand access-enable [host] [timeout <i>minutes</i>]	Enables the creation of temporary access list entries in line or global configuration mode. If the optional host keyword is <i>not</i> specified, all hosts on the entire network are allowed to set up a temporary access list entry. The dynamic access list contains the network mask to enable the new network connection.

For an example of a lock-and-key configuration, see the section “[Lock-and-Key Configuration Examples](#)” later in this chapter.

Lock-and-Key Configuration Guidelines

Before you configure lock-and-key, you should understand the guidelines discussed in the following sections:

- [Dynamic Access Lists](#)
- [Lock-and-Key Authentication](#)
- [The autocommand Command](#)

Dynamic Access Lists

Use the following guidelines for configuring dynamic access lists:

- Do *not* create more than one dynamic access list for any one access list. The software only refers to the first dynamic access list defined.
- Do *not* assign the same *dynamic-name* to another access list. Doing so instructs the software to reuse the existing list. All named entries must be globally unique within the configuration.
- Assign attributes to the dynamic access list in the same way you assign attributes for a static access list. The temporary access list entries inherit the attributes assigned to this list.
- Configure Telnet as the protocol so that users must open a Telnet session into the router to be authenticated before they can gain access through the router.
- Either define an idle timeout now with the **timeout** keyword in the **access-enable** command in the **autocommand** command, or define an absolute timeout value later with the **access-list** command. You must define either an idle timeout or an absolute timeout—otherwise, the temporary access list entry will remain configured indefinitely on the interface (even after the user has terminated their session) until the entry is removed manually by an administrator. (You could configure both idle and absolute timeouts if you wish.)
- If you configure an idle timeout, the idle timeout value should be equal to the WAN idle timeout value.
- If you configure both idle and absolute timeouts, the idle timeout value must be less than the absolute timeout value.
- If you realize that a job will run past the ACL's absolute timer, use the **access-list dynamic-extend** command to extend the absolute timer of the dynamic ACL by six minutes. This command allows you to open a new Telnet session into the router to re-authentication yourself using lock-and-key.
- The only values replaced in the temporary entry are the source or destination address, depending whether the access list was in the input access list or output access list. All other attributes, such as port, are inherited from the main dynamic access list.
- Each addition to the dynamic list is always put at the beginning of the dynamic list. You cannot specify the order of temporary access list entries.
- Temporary access list entries are never written to NVRAM.
- To manually clear or to display dynamic access lists, refer to the section “[Maintaining Lock-and-Key](#)” later in this chapter.

Lock-and-Key Authentication

There are three possible methods to configure an authentication query process. These three methods are described in this section.

**Note**

Cisco recommends that you use the TACACS+ server for your authentication query process. TACACS+ provides authentication, authorization, and accounting services. It also provides protocol support, protocol specification, and a centralized security database. Using a TACACS+ server is described in the next section, “[Method 1—Configuring a Security Server](#).”

Method 1—Configuring a Security Server

Use a network access security server such as TACACS+ server. This method requires additional configuration steps on the TACACS+ server but allows for stricter authentication queries and more sophisticated tracking capabilities.

```
Router(config-line)# login tacacs
```

Method 2—Configuring the username Command

Use the **username** command. This method is more effective because authentication is determined on a user basis.

```
Router(config)# username name {nopassword | password {mutual-password | encryption-type encryption-password}}
```

Method 3—Configuring the password and login Commands

Use the **password** and **login** commands. This method is less effective because the password is configured for the port, not for the user. Therefore, any user who knows the password can authenticate successfully.

```
Router(config-line)# password password
Router(config-line)# login local
```

The autocommand Command

Use the following guidelines for configuring the **autocommand** command:

- If you use a TACACS+ server to authenticate the user, you should configure the **autocommand** command on the TACACS+ server as a per-user autocommand. If you use local authentication, use the **autocommand** command on the line.
- Configure all virtual terminal (VTY) ports with the same **autocommand** command. Omitting an **autocommand** command on a VTY port allows a random host to gain EXEC mode access to the router and does not create a temporary access list entry in the dynamic access list.
- If you did not previously define an idle timeout with the **autocommand access-enable** command, you must define an absolute timeout now with the **access-list** command. You must define either an idle timeout or an absolute timeout—otherwise, the temporary access list entry will remain configured indefinitely on the interface (even after the user has terminated their session) until the entry is removed manually by an administrator. (You could configure both idle and absolute timeouts if you wish.)
- If you configure both idle and absolute timeouts, the absolute timeout value must be greater than the idle timeout value.

Verifying Lock-and-Key Configuration

You can verify that lock-and-key is successfully configured on the router by asking a user to test the connection. The user should be at a host that is permitted in the dynamic access list, and the user should have AAA authentication and authorization configured.

To test the connection, the user should Telnet to the router, allow the Telnet session to close, and then attempt to access a host on the other side of the router. This host must be one that is permitted by the dynamic access list. The user should access the host with an application that uses the IP protocol.

The following sample display illustrates what end-users might see if they are successfully authenticated. Notice that the Telnet connection is closed immediately after the password is entered and authenticated. The temporary access list entry is then created, and the host that initiated the Telnet session now has access inside the firewall.

```
Router% telnet corporate
Trying 172.21.52.1 ...
Connected to corporate.example.com.
Escape character is '^]'.
User Access Verification
Password:Connection closed by foreign host.
```

You can then use the **show access-lists** command at the router to view the dynamic access lists, which should include an additional entry permitting the user access through the router.

Maintaining Lock-and-Key

When lock-and-key is in use, dynamic access lists will dynamically grow and shrink as entries are added and deleted. You need to make sure that entries are being deleted in a timely way, because while entries exist, the risk of a spoofing attack is present. Also, the more entries there are, the bigger the router performance impact will be.

If you do not have an idle or absolute timeout configured, entries will remain in the dynamic access list until you manually remove them. If this is the case, make sure that you are extremely vigilant about removing entries.

Displaying Dynamic Access List Entries

You can display temporary access list entries when they are in use. After a temporary access list entry is cleared by you or by the absolute or idle timeout parameter, it can no longer be displayed. The number of matches displayed indicates the number of times the access list entry was hit.

To view dynamic access lists and any temporary access list entries that are currently established, use the following command in privileged EXEC mode:

Command	Purpose
Router# show access-lists [<i>access-list-number</i>]	Displays dynamic access lists and temporary access list entries.

Manually Deleting Dynamic Access List Entries

To manually delete a temporary access list entry, use the following command in privileged EXEC mode:

Command	Purpose
Router# clear access-template [<i>access-list-number</i> <i>name</i>] [<i>dynamic-name</i>] [<i>source</i>] [<i>destination</i>]	Deletes a dynamic access list.

Lock-and-Key Configuration Examples

The following sections provide lock-and-key configuration examples:

- [Lock-and-Key with Local Authentication Example](#)
- [Lock-and-Key with TACACS+ Authentication Example](#)

Cisco recommends that you use a TACACS+ server for authentication, as shown in the second example.

Lock-and-Key with Local Authentication Example

This example shows how to configure lock-and-key access, with authentication occurring locally at the router. Lock-and-key is configured on the Ethernet 0 interface.

```
interface ethernet0
 ip address 172.18.23.9 255.255.255.0
 ip access-group 101 in

access-list 101 permit tcp any host 172.18.21.2 eq telnet
access-list 101 dynamic mytestlist timeout 120 permit ip any any

line vty 0
 login local
 autocommand access-enable timeout 5
```

The first access-list entry allows only Telnet into the router. The second access-list entry is always ignored until lock-and-key is triggered.

In the **access-list** command, the timeout is the absolute timeout. In this example, the lifetime of the mytestlist ACL is 120 minutes; that is, when a user logs in and enable the **access-enable** command, a dynamic ACL is created for 120 minutes (the maximum absolute time). The session is closed after 120 minutes, whether or not anyone is using it.

In the **autocommand** command, the timeout is the idle timeout. In this example, each time the user logs in or authenticates there is a 5-minute session. If there is no activity, the session closes in 5 minutes and the user has to reauthenticate. If the user uses the connection, the absolute time takes affect and the session closes in 120 minutes.

After a user opens a Telnet session into the router, the router will attempt to authenticate the user. If authentication is successful, the **autocommand** executes and the Telnet session terminates. The **autocommand** creates a temporary inbound access list entry at the Ethernet 0 interface, based on the second access-list entry (mytestlist). This temporary entry will expire after 5 minutes, as specified by the timeout.

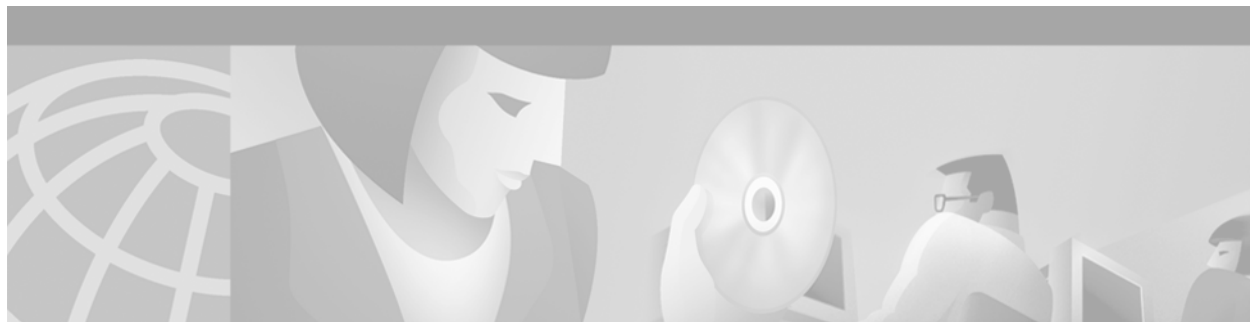
Lock-and-Key with TACACS+ Authentication Example

The following example shows how to configure lock-and-key access, with authentication on a TACACS+ server. Lock-and-key access is configured on the BRI0 interface. Four VTY ports are defined with the password “cisco”.

```

aaa authentication login default group tacacs+ enable
aaa accounting exec stop-only group tacacs+
aaa accounting network stop-only group tacacs+
enable password ciscotac
!
isdn switch-type basic-dms100
!
interface ethernet0
ip address 172.18.23.9 255.255.255.0
!
interface BRI0
ip address 172.18.21.1 255.255.255.0
encapsulation ppp
dialer idle-timeout 3600
dialer wait-for-carrier-time 100
dialer map ip 172.18.21.2 name diana
dialer-group 1
isdn spid1 2036333715291
isdn spid2 2036339371566
ppp authentication chap
ip access-group 102 in
!
access-list 102 permit tcp any host 172.18.21.2 eq telnet
access-list 102 dynamic testlist timeout 5 permit ip any any
!
!
ip route 172.18.250.0 255.255.255.0 172.18.21.2
priority-list 1 interface BRI0 high
tacacs-server host 172.18.23.21
tacacs-server host 172.18.23.14
tacacs-server key test1
tftp-server rom alias all
!
dialer-list 1 protocol ip permit
!
line con 0
password cisco
line aux 0
line VTY 0 4
autocommand access-enable timeout 5
password cisco
!

```



Configuring IP Session Filtering (Reflexive Access Lists)

This chapter describes how to configure reflexive access lists on your router. Reflexive access lists provide the ability to filter network traffic at a router, based on IP upper-layer protocol “session” information.

For a complete description of reflexive access list commands, refer to the “Reflexive Access List Commands” chapter of the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the chapter “Identifying Supported Platforms” section in the “Using Cisco IOS Software.”

In This Chapter

This chapter has the following sections:

- [About Reflexive Access Lists](#)
- [Pework: Before You Configure Reflexive Access Lists](#)
- [Reflexive Access Lists Configuration Task List](#)
- [Reflexive Access List Configuration Examples](#)

About Reflexive Access Lists

Reflexive access lists allow IP packets to be filtered based on upper-layer session information. You can use reflexive access lists to permit IP traffic for sessions originating from within your network but to deny IP traffic for sessions originating from outside your network. This is accomplished by reflexive filtering, a kind of session filtering.

Reflexive access lists can be defined with extended named IP access lists only. You cannot define reflexive access lists with numbered or standard named IP access lists or with other protocol access lists.

You can use reflexive access lists in conjunction with other standard access lists and static extended access lists.

This section has the following sections:

- [Benefits of Reflexive Access Lists](#)
- [What Is a Reflexive Access List?](#)
- [How Reflexive Access Lists Implement Session Filtering](#)
- [Where to Configure Reflexive Access Lists](#)
- [How Reflexive Access Lists Work](#)
- [Restrictions on Using Reflexive Access Lists](#)

Benefits of Reflexive Access Lists

Reflexive access lists are an important part of securing your network against network hackers, and can be included in a firewall defense. Reflexive access lists provide a level of security against spoofing and certain denial-of-service attacks. Reflexive access lists are simple to use, and, compared to basic access lists, provide greater control over which packets enter your network.

What Is a Reflexive Access List?

Reflexive access lists are similar in many ways to other access lists. Reflexive access lists contain condition statements (entries) that define criteria for permitting IP packets. These entries are evaluated in order, and when a match occurs, no more entries are evaluated.

However, reflexive access lists have significant differences from other types of access lists. Reflexive access lists contain only temporary entries; these entries are automatically created when a new IP session begins (for example, with an outbound packet), and the entries are removed when the session ends. Reflexive access lists are not themselves applied directly to an interface, but are “nested” within an extended named IP access list that is applied to the interface. (For more information about this, see the section “[Reflexive Access Lists Configuration Task List](#)” later in this chapter.) Also, reflexive access lists do not have the usual implicit “deny all traffic” statement at the end of the list, because of the nesting.

How Reflexive Access Lists Implement Session Filtering

This section compares session filtering with basic access lists to session filtering with reflexive access lists. This section contains the following sections:

- [With Basic Access Lists](#)
- [With Reflexive Access Lists](#)

With Basic Access Lists

With basic standard and static extended access lists, you can approximate session filtering by using the **established** keyword with the **permit** command. The **established** keyword filters TCP packets based on whether the ACK or RST bits are set. (Set ACK or RST bits indicate that the packet is not the first in the session, and therefore, that the packet belongs to an established session.) This filter criterion would be part of an access list applied permanently to an interface.

With Reflexive Access Lists

Reflexive access lists, however, provide a truer form of session filtering, which is much harder to spoof because more filter criteria must be matched before a packet is permitted through. (For example, source and destination addresses and port numbers are checked, not just ACK and RST bits.) Also, session filtering uses temporary filters which are removed when a session is over. This limits the hacker's attack opportunity to a smaller time window.

Moreover, the previous method of using the **established** keyword was available only for the TCP upper-layer protocol. So, for the other upper-layer protocols (such as UDP, ICMP, and so forth), you would have to either permit all incoming traffic or define all possible permissible source/destination host/port address pairs for each protocol. (Besides being an unmanageable task, this could exhaust NVRAM space.)

Where to Configure Reflexive Access Lists

Configure reflexive access lists on border routers—routers that pass traffic between an internal and external network. Often, these are firewall routers.



Note

In this chapter, the words “within your network” and “internal network” refer to a network that is controlled (secured), such as your organization's intranet, or to a part of your organization's internal network that has higher security requirements than another part. “Outside your network” and “external network” refer to a network that is uncontrolled (unsecured) such as the Internet or to a part of your organization's network that is not as highly secured.

How Reflexive Access Lists Work

A reflexive access list is triggered when a new IP upper-layer session (such as TCP or UDP) is initiated from inside your network, with a packet traveling to the external network. When triggered, the reflexive access list generates a new, temporary entry. This entry will permit traffic to enter your network if the traffic is part of the session, but will not permit traffic to enter your network if the traffic is not part of the session.

For example, if an outbound TCP packet is forwarded to outside of your network, and this packet is the first packet of a TCP session, then a new, temporary reflexive access list entry will be created. This entry is added to the reflexive access list, which applies to inbound traffic. The temporary entry has characteristics as described next.

This section contains the following sections:

- [Temporary Access List Entry Characteristics](#)
- [When the Session Ends](#)

Temporary Access List Entry Characteristics

- The entry is always a **permit** entry.
- The entry specifies the same protocol (TCP) as the original outbound TCP packet.
- The entry specifies the same source and destination addresses as the original outbound TCP packet, except the addresses are swapped.

- The entry specifies the same source and destination port numbers as the original outbound TCP packet, except the port numbers are swapped.
(This entry characteristic applies only for TCP and UDP packets. Other protocols, such as ICMP and IGMP, do not have port numbers, and other criteria are specified. For example, for ICMP, type numbers are used instead.)
- Inbound TCP traffic will be evaluated against the entry, until the entry expires. If an inbound TCP packet matches the entry, the inbound packet will be forwarded into your network.
- The entry will expire (be removed) after the last packet of the session passes through the interface.
- If no packets belonging to the session are detected for a configurable length of time (the timeout period), the entry will expire.

When the Session Ends

Temporary reflexive access list entries are removed at the end of the session. For TCP sessions, the entry is removed 5 seconds after two set FIN bits are detected, or immediately after matching a TCP packet with the RST bit set. (Two set FIN bits in a session indicate that the session is about to end; the 5-second window allows the session to close gracefully. A set RST bit indicates an abrupt session close.) Or, the temporary entry is removed after no packets of the session have been detected for a configurable length of time (the timeout period).

For UDP and other protocols, the end of the session is determined differently than for TCP. Because other protocols are considered to be connectionless (sessionless) services, there is no session tracking information embedded in packets. Therefore, the end of a session is considered to be when no packets of the session have been detected for a configurable length of time (the timeout period).

Restrictions on Using Reflexive Access Lists

Reflexive access lists do not work with some applications that use port numbers that change during a session. For example, if the port numbers for a return packet are different from the originating packet, the return packet will be denied, even if the packet is actually part of the same session.

The TCP application of FTP is an example of an application with changing port numbers. With reflexive access lists, if you start an FTP request from within your network, the request will not complete. Instead, you must use Passive FTP when originating requests from within your network.

Prework: Before You Configure Reflexive Access Lists

Before you configure reflexive access lists, you must decide whether to configure reflexive access lists on an internal or external interface, as described in the next section, “[Choosing an Interface: Internal or External](#).”

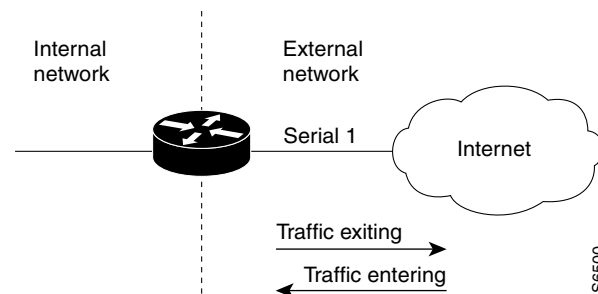
You should also be sure that you have a basic understanding of the IP protocol and of access lists; specifically, you should know how to configure extended named IP access lists. To learn about configuring IP extended access lists, refer to the “Configuring IP Services” chapter of the *Cisco IOS IP Configuration Guide*.

Choosing an Interface: Internal or External

Reflexive access lists are most commonly used with one of two basic network topologies. Determining which of these topologies is most like your own can help you decide whether to use reflexive access lists with an internal interface or with an external interface (the interface connecting to an internal network, or the interface connecting to an external network).

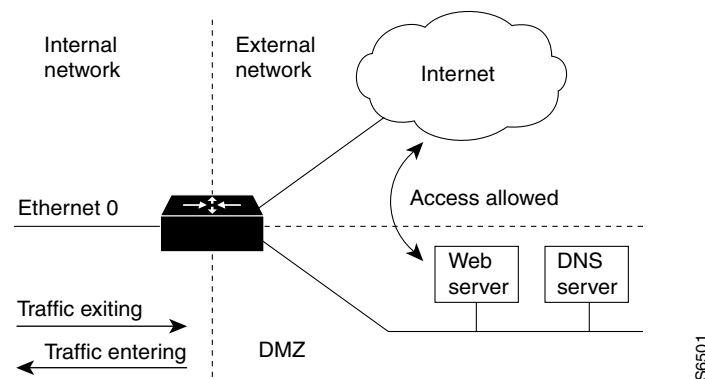
The first topology is shown in Figure 15. In this simple topology, reflexive access lists are configured for the *external* interface Serial 1. This prevents IP traffic from entering the router and the internal network, unless the traffic is part of a session already established from within the internal network.

Figure 15 Simple Topology—Reflexive Access Lists Configured at the External Interface



The second topology is shown in Figure 16. In this topology, reflexive access lists are configured for the *internal* interface Ethernet 0. This allows external traffic to access the services in the Demilitarized Zone (DMZ), such as DNS services, but prevents IP traffic from entering your internal network—unless the traffic is part of a session already established from within the internal network.

Figure 16 DMZ Topology—Reflexive Access Lists Configured at the Internal Interface



Use these two example topologies to help you decide whether to configure reflexive access lists for an internal or external interface.

Reflexive Access Lists Configuration Task List

In the previous section, “[Prework: Before You Configure Reflexive Access Lists](#),” you decided whether to configure reflexive access lists for an internal or external interface.

Now, complete the tasks in one of the following configuration task lists:

- [External Interface Configuration Task List](#)
- [Internal Interface Configuration Task List](#)

For configuration examples, refer to the “[Reflexive Access List Configuration Examples](#)” section at the end of this chapter.

External Interface Configuration Task List

To configure reflexive access lists for an external interface, perform the following tasks:

1. Defining the reflexive access list(s) in an *outbound* IP extended named access list
2. Nesting the reflexive access list(s) in an *inbound* IP extended named access list
3. Setting a global timeout value

These tasks are described in the sections following the “[Internal Interface Configuration Task List](#)” section.

**Note**

The defined (outbound) reflexive access list evaluates traffic traveling out of your network: if the defined reflexive access list is matched, temporary entries are created in the nested (inbound) reflexive access list. These temporary entries will then be applied to traffic traveling into your network.

Internal Interface Configuration Task List

To configure reflexive access lists for an internal interface, perform the following tasks:

1. Defining the reflexive access list(s) in an *inbound* IP extended named access list
2. Nesting the reflexive access list(s) in an *outbound* IP extended named access list
3. Setting a global timeout value

These tasks are described in the next sections.

**Note**

The defined (inbound) reflexive access list is used to evaluate traffic traveling out of your network: if the defined reflexive access list is matched, temporary entries are created in the nested (outbound) reflexive access list. These temporary entries will then be applied to traffic traveling into your network.

Defining the Reflexive Access List(s)

To define a reflexive access list, you use an entry in an extended named IP access list. This entry must use the **reflect** keyword.

- If you are configuring reflexive access lists for an external interface, the extended named IP access list should be one that is applied to outbound traffic.
- If you are configuring reflexive access lists for an internal interface, the extended named IP access list should be one that is applied to inbound traffic.

To define reflexive access lists, use the following commands, beginning in global configuration mode:

Command	Purpose
Step 1 Router(config)# ip access-list extended <i>name</i>	External interface: Specifies the outbound access list. or Internal interface: Specifies the inbound access list. (This command enters access-list configuration mode.)
Step 2 Router(config-ext-nacl)# permit <i>protocol any any</i> reflect <i>name</i> [timeout <i>seconds</i>]	Defines the reflexive access list using the reflexive permit entry. Repeat this step for each IP upper-layer protocol; for example, you can define reflexive filtering for TCP sessions and also for UDP sessions. You can use the same <i>name</i> for multiple protocols. For additional guidelines for this task, see the following section, “ Mixing Reflexive Access List Statements with Other Permit and Deny Entries .”

If the extended named IP access list you just specified has never been applied to the interface, you must also apply the extended named IP access list to the interface.

To apply the extended named IP access list to the interface, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# ip access-group <i>name</i> out or Router(config-if)# ip access-group <i>name</i> in	External interface: Applies the extended access list to the interface’s outbound traffic. Internal interface: Applies the extended access list to the interface’s inbound traffic.

Mixing Reflexive Access List Statements with Other Permit and Deny Entries

The extended IP access list that contains the reflexive access list **permit** statement can also contain other normal **permit** and **deny** statements (entries). However, as with all access lists, the order of entries is important, as explained in the next few paragraphs.

If you configure reflexive access lists for an external interface, when an outbound IP packet reaches the interface, the packet will be evaluated sequentially by each entry in the outbound access list until a match occurs.

If the packet matches an entry prior to the reflexive **permit** entry, the packet will not be evaluated by the reflexive **permit** entry, and no temporary entry will be created for the reflexive access list (reflexive filtering will not be triggered).

The outbound packet will be evaluated by the reflexive **permit** entry only if no other match occurs first. Then, if the packet matches the protocol specified in the reflexive **permit** entry, the packet is forwarded out of the interface and a corresponding temporary entry is created in the inbound reflexive access list (unless the corresponding entry already exists, indicating the outbound packet belongs to a session in progress). The temporary entry specifies criteria that permits inbound traffic only for the same session.

Nesting the Reflexive Access List(s)

After you define a reflexive access list in one IP extended access list, you must “nest” the reflexive access list within a different extended named IP access list.

- If you are configuring reflexive access lists for an external interface, nest the reflexive access list within an extended named IP access list applied to inbound traffic.
- If you are configuring reflexive access lists for an internal interface, nest the reflexive access list within an extended named IP access list applied to outbound traffic.

After you nest a reflexive access list, packets heading into your internal network can be evaluated against any reflexive access list temporary entries, along with the other entries in the extended named IP access list.

To nest reflexive access lists, use the following commands, beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# ip access-list extended <i>name</i>	External interface: Specifies the inbound access list. or Internal interface: Specifies the outbound access list. (This command enters access-list configuration mode.)
Step 2	Router(config-ext-nacl)# evaluate <i>name</i>	Adds an entry that “points” to the reflexive access list. Adds an entry for each reflexive access list <i>name</i> previously defined.

Again, the order of entries is important. Normally, when a packet is evaluated against entries in an access list, the entries are evaluated in sequential order, and when a match occurs, no more entries are evaluated. With a reflexive access list nested in an extended access list, the extended access list entries are evaluated sequentially up to the nested entry, then the reflexive access list entries are evaluated sequentially, and then the remaining entries in the extended access list are evaluated sequentially. As usual, after a packet matches *any* of these entries, no more entries will be evaluated.

If the extended named IP access list you just specified has never been applied to the interface, you must also apply the extended named IP access list to the interface.

To apply the extended named IP access list to the interface, use one of the following commands in interface configuration mode:

Command	Purpose
Router(config-if)# ip access-group <i>name</i> in	External interface: Applies the extended access list to the interface's inbound traffic.
or	
Router(config-if)# ip access-group <i>name</i> out	Internal interface: Applies the extended access list to the interface's outbound traffic.

Setting a Global Timeout Value

Reflexive access list entries expire after no packets in the session have been detected for a certain length of time (the “timeout” period). You can specify the timeout for a particular reflexive access list when you define the reflexive access list. But if you do not specify the timeout for a given reflexive access list, the list will use the global timeout value instead.

The global timeout value is 300 seconds by default. But, you can change the global timeout to a different value at any time.

To change the global timeout value, use the following command in global configuration mode:

Command	Purpose
Router(config)# ip reflexive-list timeout <i>seconds</i>	Changes the global timeout value for temporary reflexive access list entries. Use a positive integer from 0 to 2,147,483.

Reflexive Access List Configuration Examples

The following sections provide reflexive access list configuration examples:

- [External Interface Configuration Example](#)
- [Internal Interface Configuration Example](#)

External Interface Configuration Example

This example shows reflexive access lists configured for an external interface, for a topology similar to the one in [Figure 15](#) (shown earlier in this chapter).

This configuration example permits both inbound and outbound TCP traffic at interface Serial 1, but only if the first packet (in a given session) originated from inside your network. The interface Serial 1 connects to the Internet.

Define the interface where the session-filtering configuration is to be applied:

```
interface serial 1
  description Access to the Internet via this interface
```

Apply access lists to the interface, for inbound traffic and for outbound traffic:

```
ip access-group inboundfilters in
ip access-group outboundfilters out
```

Define the outbound access list. This is the access list that evaluates all outbound traffic on interface Serial 1.

```
ip access-list extended outboundfilters
```

Define the reflexive access list *tcptraffic*. This entry permits *all* outbound TCP traffic and creates a new access list named *tcptraffic*. Also, when an outbound TCP packet is the first in a new session, a corresponding temporary entry will be automatically created in the reflexive access list *tcptraffic*.

```
permit tcp any any reflect tcptraffic
```

Define the inbound access list. This is the access list that evaluates all inbound traffic on interface Serial 1.

```
ip access-list extended inboundfilters
```

Define the inbound access list entries. This example shows Enhanced IGRP packets allowed on the interface. Also, no ICMP traffic is permitted. The last entry points to the reflexive access list. If a packet does not match the first two entries, the packet will be evaluated against all the entries in the reflexive access list *tcptraffic*.

```
permit eigrp any any
deny icmp any any
evaluate tcptraffic
```

Define the global idle timeout value for all reflexive access lists. In this example, when the reflexive access list *tcptraffic* was defined, no timeout was specified, so *tcptraffic* uses the global timeout. Therefore, if for 120 seconds there is no TCP traffic that is part of an established session, the corresponding reflexive access list entry will be removed.

```
ip reflexive-list timeout 120
```

The example configuration looks as follows:

```
interface Serial 1
  description Access to the Internet via this interface
  ip access-group inboundfilters in
  ip access-group outboundfilters out
!
ip reflexive-list timeout 120
!
ip access-list extended outboundfilters
  permit tcp any any reflect tcptraffic
!
ip access-list extended inboundfilters
  permit eigrp any any
  deny icmp any any
  evaluate tcptraffic
```

With this configuration, before any TCP sessions have been initiated the **show access-list EXEC** command displays the following:

```
Extended IP access list inboundfilters
  permit eigrp any any
  deny icmp any any
  evaluate tcptraffic
Extended IP access list outboundfilters
  permit tcp any any reflect tcptraffic
```

Notice that the reflexive access list does not appear in this output. This is because before any TCP sessions have been initiated, no traffic has triggered the reflexive access list, and the list is empty (has no entries). When empty, reflexive access lists do not show up in **show access-list** output.

After a Telnet connection is initiated from within your network to a destination outside of your network, the **show access-list EXEC** command displays the following:

```
Extended IP access list inboundfilters
  permit eigrp any any
  deny icmp any any
  evaluate tcptraffic
Extended IP access list outboundfilters
  permit tcp any any reflect tcptraffic
Reflexive IP access list tcptraffic
  permit tcp host 172.19.99.67 eq telnet host 192.168.60.185 eq 11005 (5 matches) (time
left 115 seconds)
```

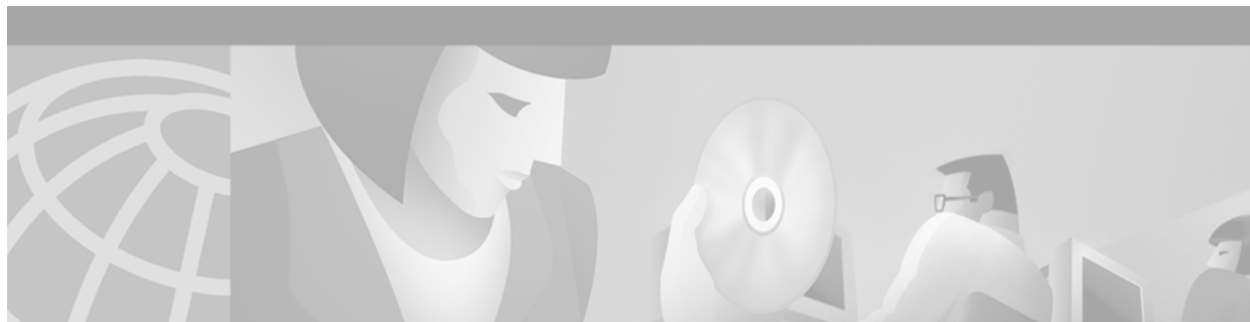
Notice that the reflexive access list *tcptraffic* now appears and displays the temporary entry generated when the Telnet session initiated with an outbound packet.

Internal Interface Configuration Example

This is an example configuration for reflexive access lists configured for an internal interface. This example has a topology similar to the one in [Figure 16](#) (shown earlier in this chapter).

This example is similar to the previous example; the only difference between this example and the previous example is that the entries for the outbound and inbound access lists are swapped. Please refer to the previous example for more details and descriptions.

```
interface Ethernet 0
  description Access from the I-net to our Internal Network via this interface
  ip access-group inboundfilters in
  ip access-group outboundfilters out
  !
ip reflexive-list timeout 120
!
ip access-list extended outboundfilters
  permit eigrp any any
  deny icmp any any
  evaluate tcptraffic
!
ip access-list extended inboundfilters
  permit tcp any any reflect tcptraffic
```

Configuring TCP Intercept (Preventing Denial-of-Service Attacks)

This chapter describes how to configure your router to protect TCP servers from TCP SYN-flooding attacks, a type of denial-of-service attack. This is accomplished by configuring the Cisco IOS feature known as TCP Intercept.

For a complete description of TCP Intercept commands, refer to the “TCP Intercept Commands” chapter of the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the chapter “Identifying Supported Platforms” section in the “Using Cisco IOS Software.”

In This Chapter

This chapter has the following sections:

- [About TCP Intercept](#)
- [TCP Intercept Configuration Task List](#)
- [TCP Intercept Configuration Example](#)

About TCP Intercept

The TCP intercept feature implements software to protect TCP servers from TCP SYN-flooding attacks, which are a type of denial-of-service attack.

A SYN-flooding attack occurs when a hacker floods a server with a barrage of requests for connection. Because these messages have unreachable return addresses, the connections cannot be established. The resulting volume of unresolved open connections eventually overwhelms the server and can cause it to deny service to valid requests, thereby preventing legitimate users from connecting to a web site, accessing e-mail, using FTP service, and so on.

The TCP intercept feature helps prevent SYN-flooding attacks by intercepting and validating TCP connection requests. In intercept mode, the TCP intercept software intercepts TCP synchronization (SYN) packets from clients to servers that match an extended access list. The software establishes a connection with the client on behalf of the destination server, and if successful, establishes the

connection with the server on behalf of the client and knits the two half-connections together transparently. Thus, connection attempts from unreachable hosts will never reach the server. The software continues to intercept and forward packets throughout the duration of the connection. The number of SYN's per second and the number of concurrent connections proxied depends on the platform, memory, processor, and other factors

In the case of illegitimate requests, the software's aggressive timeouts on half-open connections and its thresholds on TCP connection requests protect destination servers while still allowing valid requests.

When establishing your security policy using TCP intercept, you can choose to intercept all requests or only those coming from specific networks or destined for specific servers. You can also configure the connection rate and threshold of outstanding connections.

You can choose to operate TCP intercept in watch mode, as opposed to intercept mode. In watch mode, the software passively watches the connection requests flowing through the router. If a connection fails to get established in a configurable interval, the software intervenes and terminates the connection attempt.

TCP options that are negotiated on handshake (such as RFC 1323 on window scaling) will not be negotiated because the TCP intercept software does not know what the server can do or will negotiate.

TCP Intercept Configuration Task List

To configure TCP intercept, perform the tasks in the following sections. The first task is required; the rest are optional.

- [Enabling TCP Intercept](#) (Required)
- [Setting the TCP Intercept Mode](#) (Optional)
- [Setting the TCP Intercept Drop Mode](#) (Optional)
- [Changing the TCP Intercept Timers](#) (Optional)
- [Changing the TCP Intercept Aggressive Thresholds](#) (Optional)
- [Monitoring and Maintaining TCP Intercept](#) (Optional)

For TCP intercept configuration examples using the commands in this chapter, refer to the “[TCP Intercept Configuration Example](#)” section at the end of this chapter.

Enabling TCP Intercept

To enable TCP intercept, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# access-list <i>access-list-number</i> {deny permit} tcp any <i>destination destination-wildcard</i>	Defines an IP extended access list.
Step 2	Router(config)# ip tcp intercept list <i>access-list-number</i>	Enables TCP intercept.

You can define an access list to intercept all requests or only those coming from specific networks or destined for specific servers. Typically the access list will define the source as **any** and define specific destination networks or servers. That is, you do not attempt to filter on the source addresses because you do not necessarily know who to intercept packets from. You identify the destination in order to protect destination servers.

If no access list match is found, the router allows the request to pass with no further action.

Setting the TCP Intercept Mode

The TCP intercept can operate in either active intercept mode or passive watch mode. The default is intercept mode.

In intercept mode, the software actively intercepts each incoming connection request (SYN) and responds on behalf of the server with an SYN-ACK, then waits for an ACK from the client. When that ACK is received, the original SYN is sent to the server and the software performs a three-way handshake with the server. When this is complete, the two half-connections are joined.

In watch mode, connection requests are allowed to pass through the router to the server but are watched until they become established. If they fail to become established within 30 seconds (configurable with the **ip tcp intercept watch-timeout** command), the software sends a Reset to the server to clear up its state.

To set the TCP intercept mode, use the following command in global configuration mode:

Command	Purpose
Router(config)# ip tcp intercept mode { intercept watch }	Sets the TCP intercept mode.

Setting the TCP Intercept Drop Mode

When under attack, the TCP intercept feature becomes more aggressive in its protective behavior. If the number of incomplete connections exceeds 1100 or the number of connections arriving in the last one minute exceeds 1100, each new arriving connection causes the oldest partial connection to be deleted. Also, the initial retransmission timeout is reduced by half to 0.5 seconds (so the total time trying to establish a connection is cut in half).

By default, the software drops the oldest partial connection. Alternatively, you can configure the software to drop a random connection. To set the drop mode, use the following command in global configuration mode:

Command	Purpose
Router(config)# ip tcp intercept drop-mode { oldest random }	Sets the drop mode.

Changing the TCP Intercept Timers

By default, the software waits for 30 seconds for a watched connection to reach established state before sending a Reset to the server. To change this value, use the following command in global configuration mode:

Command	Purpose
Router(config)# ip tcp intercept watch-timeout <i>seconds</i>	Changes the time allowed to reach established state.

By default, the software waits for 5 seconds from receipt of a reset or FIN-exchange before it ceases to manage the connection. To change this value, use the following command in global configuration mode:

Command	Purpose
Router(config)# ip tcp intercept finrst-timeout <i>seconds</i>	Changes the time between receipt of a reset or FIN-exchange and dropping the connection.

By default, the software still manages a connection for 24 hours after no activity. To change this value, use the following command in global configuration mode:

Command	Purpose
Router(config)# ip tcp intercept connection-timeout <i>seconds</i>	Changes the time the software will manage a connection after no activity.

Changing the TCP Intercept Aggressive Thresholds

Two factors determine when aggressive behavior begins and ends: total incomplete connections and connection requests during the last one-minute sample period. Both thresholds have default values that can be redefined.

When a threshold is exceeded, the TCP intercept assumes the server is under attack and goes into aggressive mode. When in aggressive mode, the following occurs:

- Each new arriving connection causes the oldest partial connection to be deleted. (You can change to a random drop mode.)
- The initial retransmission timeout is reduced by half to 0.5 seconds, and so the total time trying to establish the connection is cut in half. (When not in aggressive mode, the code does exponential back-off on its retransmissions of SYN segments. The initial retransmission timeout is 1 second. The subsequent timeouts are 2 seconds, 4 seconds, 8 seconds, and 16 seconds. The code retransmits 4 times before giving up, so it gives up after 31 seconds of no acknowledgment.)
- If in watch mode, the watch timeout is reduced by half. (If the default is in place, the watch timeout becomes 15 seconds.)

The drop strategy can be changed from the oldest connection to a random connection with the **ip tcp intercept drop-mode** command.



Note

The two factors that determine aggressive behavior are related and work together. When *either* of the **high** values is exceeded, aggressive behavior begins. When *both* quantities fall below the **low** value, aggressive behavior ends.

You can change the threshold for triggering aggressive mode based on the total number of incomplete connections. The default values for **low** and **high** are 900 and 1100 incomplete connections, respectively. To change these values, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# ip tcp intercept max-incomplete low <i>number</i>	Sets the threshold for stopping aggressive mode.
Step 2	Router(config)# ip tcp intercept max-incomplete high <i>number</i>	Sets the threshold for triggering aggressive mode.

You can also change the threshold for triggering aggressive mode based on the number of connection requests received in the last 1-minute sample period. The default values for **low** and **high** are 900 and 1100 connection requests, respectively. To change these values, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# ip tcp intercept one-minute low <i>number</i>	Sets the threshold for stopping aggressive mode.
Step 2	Router(config)# ip tcp intercept one-minute high <i>number</i>	Sets the threshold for triggering aggressive mode.

Monitoring and Maintaining TCP Intercept

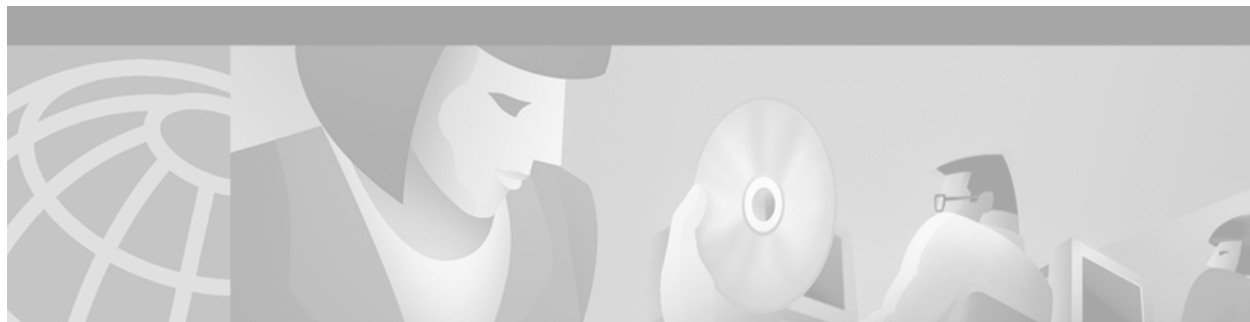
To display TCP intercept information, use either of the following commands in EXEC mode:

Command	Purpose
Router# show tcp intercept connections	Displays incomplete connections and established connections.
Router# show tcp intercept statistics	Displays TCP intercept statistics.

TCP Intercept Configuration Example

The following configuration defines extended IP access list 101, causing the software to intercept packets for all TCP servers on the 192.168.1.0/24 subnet:

```
ip tcp intercept list 101
!
access-list 101 permit tcp any 192.168.1.0 0.0.0.255
```

Configuring Cisco IOS Firewall Intrusion Detection System

This chapter describes the Cisco IOS Firewall Intrusion Detection System (IDS) feature. Intrusion detection systems provide a level of protection beyond the firewall by protecting the network from internal and external attacks and threats. Cisco IOS Firewall IDS technology enhances perimeter firewall protection by taking appropriate action on packets and flows that violate the security policy or represent malicious network activity.

For a complete description of the Cisco IOS Firewall IDS commands in this chapter, refer to the “Cisco IOS Firewall IDS Commands” chapter of the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the chapter “Identifying Supported Platforms” section in the “Using Cisco IOS Software.”

In This Chapter

This chapter has the following sections:

- [About the Firewall Intrusion Detection System](#)
- [Cisco IOS Firewall IDS Configuration Task List](#)
- [Monitoring and Maintaining Cisco IOS Firewall IDS](#)
- [Cisco IOS Firewall IDS Configuration Examples](#)

About the Firewall Intrusion Detection System

The Cisco IOS Firewall IDS feature supports intrusion detection technology for midrange and high-end router platforms with firewall support. It is ideal for any network perimeter, and especially for locations in which a router is being deployed and additional security between network segments is required. It also can protect intranet and extranet connections where additional security is mandated, and branch-office sites connecting to the corporate office or Internet.

The Cisco IOS Firewall IDS feature identifies 59 of the most common attacks using “signatures” to detect patterns of misuse in network traffic. The intrusion-detection signatures included in the Cisco IOS Firewall were chosen from a broad cross-section of intrusion-detection signatures. The signatures represent severe breaches of security and the most common network attacks and information-gathering scans. For a description of Cisco IOS Firewall IDS signatures, refer to the “[Cisco IOS Firewall IDS Signature List](#)” section.

The Cisco IOS Firewall IDS acts as an in-line intrusion detection sensor, watching packets and sessions as they flow through the router, scanning each to match any of the IDS signatures. IDS monitors packets and send alarms when suspicious activity is detected. IDS logs the event through Cisco IOS syslog or the Cisco Secure Intrusion Detection System (Cisco Secure IDS, formerly known as NetRanger) Post Office Protocol. The network administrator can configure the IDS system to choose the appropriate response to various threats. When packets in a session match a signature, the IDS system can be configured to take these actions:

- Send an alarm to a syslog server or a Cisco Secure IDS Director (centralized management interface)
- Drop the packet
- Reset the TCP connection

Cisco developed its Cisco IOS software-based intrusion-detection capabilities in Cisco IOS Firewall with flexibility in mind, so that individual signatures could be disabled in case of false positives. Also, while it is preferable to enable both the firewall and intrusion detection features of the CBAC security engine to support a network security policy, each of these features may be enabled independently and on different router interfaces. Cisco IOS software-based intrusion detection is part of the Cisco IOS Firewall.

This section has the following sections:

- [Interaction with Cisco IOS Firewall Default Parameters](#)
- [Compatibility with Cisco Secure Intrusion Detection](#)
- [Functional Description](#)
- [When to Use Cisco IOS Firewall IDS](#)
- [Memory and Performance Impact](#)
- [Cisco IOS Firewall IDS Signature List](#)

Interaction with Cisco IOS Firewall Default Parameters

When Cisco IOS IDS is enabled, Cisco IOS Firewall is automatically enabled. Thus, IDS uses Cisco IOS Firewall default parameter values to inspect incoming sessions. Default parameter values include the following:

- The rate at which IDS starts deleting half-open sessions (modified via the **ip inspect one-minute high** command)
- The rate at which IDS stops deleting half-open sessions (modified via the **ip inspect one-minute low** command)
- The maximum incomplete sessions (modified via the **ip inspect max-incomplete high** and the **ip inspect max-incomplete low** commands)

After the incoming TCP session setup rate crosses the one-minute high water mark, the router will reset the oldest half-open session, which is the default behavior of the Cisco IOS Firewall. Cisco IOS IDS cannot modify this default behavior. Thus, after a new TCP session rate crosses the one-minute high

water mark and a router attempts to open new connections by sending SYN packets at the same time, the latest SYN packet will cause the router to reset the half-open session that was opened by the earlier SYN packet. Only the last SYN request will survive.

Compatibility with Cisco Secure Intrusion Detection

Cisco IOS Firewall is compatible with the Cisco Secure Intrusion Detection System (formally known as NetRanger). The Cisco Secure IDS is an enterprise-scale, real-time, intrusion detection system designed to detect, report, and terminate unauthorized activity throughout a network.

The Cisco Secure IDS consists of three components:

- Sensor
- Director
- Post Office

Cisco Secure IDS Sensors, which are high-speed network appliances, analyze the content and context of individual packets to determine if traffic is authorized. If a network's data stream exhibits unauthorized or suspicious activity, such as a SATAN attack, a ping sweep, or the transmission of a secret research project code word, Cisco Secure IDS Sensors can detect the policy violation in real time, forward alarms to a Cisco Secure IDS Director management console, and remove the offender from the network.

The Cisco Secure IDS Director is a high-performance, software-based management system that centrally monitors the activity of multiple Cisco Secure IDS Sensors located on local or remote network segments.

The Cisco Secure IDS Post Office is the communication backbone that allows Cisco Secure IDS services and hosts to communicate with each other. All communication is supported by a proprietary, connection-based protocol that can switch between alternate routes to maintain point-to-point connections.

Cisco Secure IDS customers can deploy the Cisco IOS Firewall IDS signatures to complement their existing IDS systems. This allows an IDS to be deployed to areas that may not be capable of supporting a Cisco Secure IDS Sensor. Cisco IOS Firewall IDS signatures can be deployed alongside or independently of other Cisco IOS Firewall features.

The Cisco IOS Firewall IDS can be added to the Cisco Secure IDS Director screen as an icon to provide a consistent view of all intrusion detection sensors throughout a network. The Cisco IOS Firewall intrusion detection capabilities have an enhanced reporting mechanism that permits logging to the Cisco Secure IDS Director console in addition to Cisco IOS syslog.

For additional information about Cisco Secure IDS (NetRanger), refer to the *NetRanger User Guide*.

Functional Description

The Cisco IOS Firewall IDS acts as an in-line intrusion detection sensor, watching packets as they traverse the router's interfaces and acting upon them in a definable fashion. When a packet, or a number of packets in a session, match a signature, the Cisco IOS Firewall IDS may perform the following configurable actions:

- Alarm—Sends an alarm to a syslog server or Cisco Secure IDS Director
- Drop—Drops the packet
- Reset—Resets the TCP connection

The following describes the packet auditing process with Cisco IOS Firewall IDS:

- You create an audit rule, which specifies the signatures that should be applied to packet traffic and the actions to take when a match is found. An audit rule can apply informational and attack signatures to network packets. The signature list can have just one signature, all signatures, or any number of signatures in between. Signatures can be disabled in case of false positives or the needs of the network environment.
- You apply the audit rule to an interface on the router, specifying a traffic direction (*in* or *out*).
- If the audit rule is applied to the *in* direction of the interface, packets passing through the interface are audited before the inbound ACL has a chance to discard them. This allows an administrator to be alerted if an attack or information-gathering activity is underway even if the router would normally reject the activity.
- If the audit rule is applied to the *out* direction on the interface, packets are audited after they enter the router through another interface. In this case, the inbound ACL of the other interface may discard packets before they are audited. This may result in the loss of Cisco IOS Firewall IDS alarms even though the attack or information-gathering activity was thwarted.
- Packets going through the interface that match the audit rule are audited by a series of modules, starting with IP; then either ICMP, TCP, or UDP (as appropriate); and finally, the Application level.
- If a signature match is found in a module, then the following user-configured action(s) occur:
 - If the action is **alarm**, then the module completes its audit, sends an alarm, and passes the packet to the next module.
 - If the action is **drop**, then the packet is dropped from the module, discarded, and not sent to the next module.
 - If the action is **reset**, then the packets are forwarded to the next module, and packets with the reset flag set are sent to both participants of the session, if the session is TCP.


Note

It is recommended that you use the **drop** and **reset** actions together.

If there are multiple signature matches in a module, only the first match fires an action. Additional matches in other modules fire additional alarms, but only one per module.


Note

This process is different than on the Cisco Secure IDS Sensor appliance, which identifies all signature matches for each packet.

When to Use Cisco IOS Firewall IDS

Cisco IOS Firewall IDS capabilities are ideal for providing additional visibility at intranet, extranet, and branch-office Internet perimeters. Network administrators enjoy more robust protection against attacks on the network and can automatically respond to threats from internal or external hosts.

The Cisco IOS Firewall with intrusion detection is intended to satisfy the security goals of all of our customers, and is particularly appropriate for the following scenarios:

- Enterprise customers that are interested in a cost-effective method of extending their perimeter security across all network boundaries, specifically branch-office, intranet, and extranet perimeters.
- Small and medium-sized businesses that are looking for a cost-effective router that has an integrated firewall with intrusion-detection capabilities.

- Service provider customers that want to set up managed services, providing firewalling and intrusion detection to their customers, all housed within the necessary function of a router.

Memory and Performance Impact

The performance impact of intrusion detection will depend on the configuration of the signatures, the level of traffic on the router, the router platform, and other individual features enabled on the router such as encryption, source route bridging, and so on. Enabling or disabling individual signatures will not alter performance significantly, however, signatures that are configured to use Access Control Lists will have a significant performance impact.

Because this router is being used as a security device, no packet will be allowed to bypass the security mechanisms. The IDS process in the Cisco IOS Firewall router sits directly in the packet path and thus will search each packet for signature matches. In some cases, the entire packet will need to be searched, and state information and even application state and awareness must be maintained by the router.

For auditing atomic signatures, there is no traffic-dependent memory requirement. For auditing compound signatures, CBAC allocates memory to maintain the state of each session for each connection. Memory is also allocated for the configuration database and for internal caching.

Cisco IOS Firewall IDS Signature List

The following is a complete list of Cisco IOS Firewall IDS signatures. A signature detects patterns of misuse in network traffic. In Cisco IOS Firewall IDS, signatures are categorized into four types:

- Info Atomic
- Info Compound
- Attack Atomic
- Attack Compound

An info signature detects information-gathering activity, such as a port sweep.

An attack signature detects attacks attempted into the protected network, such as denial-of-service attempts or the execution of illegal commands during an FTP session.

Info and attack signatures can be either atomic or compound signatures. Atomic signatures can detect patterns as simple as an attempt to access a specific port on a specific host. Compound signatures can detect complex patterns, such as a sequence of operations distributed across multiple hosts over an arbitrary period of time.

The intrusion-detection signatures included in the Cisco IOS Firewall were chosen from a broad cross-section of intrusion-detection signatures as representative of the most common network attacks and information-gathering scans that are not commonly found in an operational network.

The following signatures are listed in numerical order by their signature number in the Cisco Secure IDS Network Security Database. After each signature's name is an indication of the type of signature (info or attack, atomic or compound).



Note

Atomic signatures marked with an asterisk (Atomic*) are allocated memory for session states by CBAC.

1000 IP options-Bad Option List (Info, Atomic)

Triggers on receipt of an IP datagram where the list of IP options in the IP datagram header is incomplete or malformed. The IP options list contains one or more options that perform various network management or debugging tasks.

1001 IP options-Record Packet Route (Info, Atomic)

Triggers on receipt of an IP datagram where the IP option list for the datagram includes option 7 (Record Packet Route).

1002 IP options-Timestamp (Info, Atomic)

Triggers on receipt of an IP datagram where the IP option list for the datagram includes option 4 (Timestamp).

1003 IP options-Provide s,c,h,tcc (Info, Atomic)

Triggers on receipt of an IP datagram where the IP option list for the datagram includes option 2 (Security options).

1004 IP options-Loose Source Route (Info, Atomic)

Triggers on receipt of an IP datagram where the IP option list for the datagram includes option 3 (Loose Source Route).

1005 IP options-SATNET ID (Info, Atomic)

Triggers on receipt of an IP datagram where the IP option list for the datagram includes option 8 (SATNET stream identifier).

1006 IP options-Strict Source Route (Info, Atomic)

Triggers on receipt of an IP datagram in which the IP option list for the datagram includes option 2 (Strict Source Routing).

1100 IP Fragment Attack (Attack, Atomic)

Triggers when any IP datagram is received with the “more fragments” flag set to 1 or if there is an offset indicated in the offset field.

1101 Unknown IP Protocol (Attack, Atomic)

Triggers when an IP datagram is received with the protocol field set to 101 or greater. These protocol types are undefined or reserved and should not be used.

1102 Impossible IP Packet (Attack, Atomic)

This triggers when an IP packet arrives with source equal to destination address. This signature will catch the so-called Land Attack.

2000 ICMP Echo Reply (Info, Atomic)

Triggers when a IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 0 (Echo Reply).

2001 ICMP Host Unreachable (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 3 (Host Unreachable).

2002 ICMP Source Quench (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 4 (Source Quench).

2003 ICMP Redirect (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 5 (Redirect).

2004 ICMP Echo Request (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 8 (Echo Request).

2005 ICMP Time Exceeded for a Datagram (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 11 (Time Exceeded for a Datagram).

2006 ICMP Parameter Problem on Datagram (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 12 (Parameter Problem on Datagram).

2007 ICMP Timestamp Request (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 13 (Timestamp Request).

2008 ICMP Timestamp Reply (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 14 (Timestamp Reply).

2009 ICMP Information Request (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 15 (Information Request).

2010 ICMP Information Reply (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 16 (ICMP Information Reply).

2011 ICMP Address Mask Request (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 17 (Address Mask Request).

2012 ICMP Address Mask Reply (Info, Atomic)

Triggers when an IP datagram is received with the “protocol” field in the IP header set to 1 (ICMP) and the “type” field in the ICMP header set to 18 (Address Mask Reply).

2150 Fragmented ICMP Traffic (Attack, Atomic)

Triggers when an IP datagram is received with the protocol field in the IP header set to 1 (ICMP) and either the more fragments flag is set to 1 (ICMP) or there is an offset indicated in the offset field.

2151 Large ICMP Traffic (Attack, Atomic)

Triggers when an IP datagram is received with the protocol field in the IP header set to 1 (ICMP) and the IP length is greater than 1024.

2154 Ping of Death Attack (Attack, Atomic)

Triggers when an IP datagram is received with the protocol field in the IP header set to 1 (ICMP), the Last Fragment bit is set, and

$$(\text{IP offset} * 8) + (\text{IP data length}) > 65535$$

In other words, the IP offset (which represents the starting position of this fragment in the original packet, and which is in 8-byte units) plus the rest of the packet is greater than the maximum size for an IP packet.

3040 TCP - no bits set in flags (Attack, Atomic)

Triggers when a TCP packet is received with no bits set in the flags field.

3041 TCP - SYN and FIN bits set (Attack, Atomic)

Triggers when a TCP packet is received with both the SYN and FIN bits set in the flag field.

3042 TCP - FIN bit with no ACK bit in flags (Attack, Atomic)

Triggers when a TCP packet is received with the FIN bit set but with no ACK bit set in the flags field.

3050 Half-open SYN Attack/SYN Flood (Attack, Compound)

Triggers when multiple TCP sessions have been improperly initiated on any of several well-known service ports. Detection of this signature is currently limited to FTP, Telnet, HTTP, and e-mail servers (TCP ports 21, 23, 80, and 25 respectively).

3100 Smail Attack (Attack, Compound)

Triggers on the very common “smail” attack against SMTP-compliant e-mail servers (frequently sendmail).

3101 Sendmail Invalid Recipient (Attack, Compound)

Triggers on any mail message with a “pipe” (|) symbol in the recipient field.

3102 Sendmail Invalid Sender (Attack, Compound)

Triggers on any mail message with a “pipe” (|) symbol in the “From:” field.

3103 Sendmail Reconnaissance (Attack, Compound)

Triggers when “expn” or “vrfy” commands are issued to the SMTP port.

3104 Archaic Sendmail Attacks (Attack, Compound)

Triggers when “wiz” or “debug” commands are issued to the SMTP port.

3105 Sendmail Decode Alias (Attack, Compound)

Triggers on any mail message with “: decode@” in the header.

3106 Mail Spam (Attack, Compound)

Counts number of Rcpt to: lines in a single mail message and alarms after a user-definable maximum has been exceeded (default is 250).

3107 Majordomo Execute Attack (Attack, Compound)

A bug in the Majordomo program will allow remote users to execute arbitrary commands at the privilege level of the server.

3150 FTP Remote Command Execution (Attack, Compound)

Triggers when someone tries to execute the FTP SITE command.

3151 FTP SYST Command Attempt (Info, Compound)

Triggers when someone tries to execute the FTP SYST command.

3152 FTP CWD ~root (Attack, Compound)

Triggers when someone tries to execute the CWD ~root command.

3153 FTP Improper Address Specified (Attack, Atomic*)

Triggers if a port command is issued with an address that is not the same as the requesting host.

3154 FTP Improper Port Specified (Attack, Atomic*)

Triggers if a port command is issued with a data port specified that is less than 1024 or greater than 65535.

4050 UDP Bomb (Attack, Atomic)

Triggers when the UDP length specified is less than the IP length specified.

4100 Tftp Passwd File (Attack, Compound)

Triggers on an attempt to access the passwd file (typically /etc/passwd) via TFTP.

6100 RPC Port Registration (Info, Atomic*)

Triggers when attempts are made to register new RPC services on a target host.

6101 RPC Port Unregistration (Info, Atomic*)

Triggers when attempts are made to unregister existing RPC services on a target host.

6102 RPC Dump (Info, Atomic*)

Triggers when an RPC dump request is issued to a target host.

6103 Proxied RPC Request (Attack, Atomic*)

Triggers when a proxied RPC request is sent to the portmapper of a target host.

6150 ypserv Portmap Request (Info, Atomic*)

Triggers when a request is made to the portmapper for the YP server daemon (ypserv) port.

6151 ypbind Portmap Request (Info, Atomic*)

Triggers when a request is made to the portmapper for the YP bind daemon (ypbind) port.

6152 yppasswdd Portmap Request (Info, Atomic*)

Triggers when a request is made to the portmapper for the YP password daemon (yppasswdd) port.

6153 ypupdated Portmap Request (Info, Atomic*)

Triggers when a request is made to the portmapper for the YP update daemon (ypupdated) port.

6154 ypxfrd Portmap Request (Info, Atomic*)

Triggers when a request is made to the portmapper for the YP transfer daemon (ypxfrd) port.

6155 mountd Portmap Request (Info, Atomic*)

Triggers when a request is made to the portmapper for the mount daemon (mountd) port.

6175 rexd Portmap Request (Info, Atomic*)

Triggers when a request is made to the portmapper for the remote execution daemon (rex) port.

6180 rexd Attempt (Info, Atomic*)

Triggers when a call to the rexd program is made. The remote execution daemon is the server responsible for remote program execution. This may be indicative of an attempt to gain unauthorized access to system resources.

6190 statd Buffer Overflow (Attack, Atomic*)

Triggers when a large statd request is sent. This could be an attempt to overflow a buffer and gain access to system resources.

8000 FTP Retrieve Password File (Attack, Atomic*)

SubSig ID: 2101

Triggers on string “passwd” issued during an FTP session. May indicate someone attempting to retrieve the password file from a machine in order to crack it and gain unauthorized access to system resources.

Cisco IOS Firewall IDS Configuration Task List

See the following sections for configuration tasks for the Cisco IOS Firewall Intrusion Detection System feature. Each task in the list is identified as optional or required:

- [Initializing Cisco IOS Firewall IDS](#) (Required)
- [Initializing the Post Office](#) (Required)
- [Configuring and Applying Audit Rules](#) (Required)
- [Verifying the Configuration](#) (Optional)

For examples using the commands in this chapter, see the “[Cisco IOS Firewall IDS Configuration Examples](#)” section at the end of this chapter.

Initializing Cisco IOS Firewall IDS

To initialize Cisco IOS Firewall IDS on a router, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# ip audit smtp spam recipients	Sets the threshold beyond which spamming in e-mail messages is suspected. Here, <i>recipients</i> is the maximum number of recipients in an e-mail message. The default is 250.
Step 2	Router(config)# ip audit po max-events number_events	Sets the threshold beyond which queued events are dropped from the queue for sending to the Cisco Secure IDS Director. Here, <i>number_events</i> is the number of events in the event queue. The default is 100. Increasing this number may have an impact on memory and performance, as each event in the event queue requires 32 KB of memory.
Step 3	Router(config)# exit	Exits global configuration mode.

Initializing the Post Office



Note

You must reload the router every time you make a Post Office configuration change.

To initialize the Post Office system, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# ip audit notify nr-director or Router(config)# ip audit notify log	Sends event notifications (alarms) to either a Cisco Secure IDS Director, a syslog server, or both. For example, if you are sending alarms to a Cisco Secure IDS Director, use the nr-director keyword in the command syntax. If you are sending alarms to a syslog server, use the log keyword in the command syntax.
Step 2	router(config)# ip audit po local hostid host-id orgid org-id	Sets the Post Office parameters for both the router (using the ip audit po local command) and the Cisco Secure IDS Director (using the ip audit po remote command). Here, <i>host-id</i> is a unique number between 1 and 65535 that identifies the router, and <i>org-id</i> is a unique number between 1 and 65535 that identifies the organization to which the router and Director both belong.

	Command	Purpose
Step 3	<pre>Router(config)# ip audit po remote hostid host-id orgid org-id rmtaddress ip-address localaddress ip-address port port-number preference preference-number timeout seconds application application-type</pre>	<p>Sets the Post Office parameters for both the Cisco Secure IDS Director (using the ip audit po remote command).</p> <ul style="list-style-type: none"> <i>host-id</i> is a unique number between 1 and 65535 that identifies the Director. <i>org-id</i> is a unique number between 1 and 65535 that identifies the organization to which the router and Director both belong. rmtaddress <i>ip-address</i> is the Director's IP address. localaddress <i>ip-address</i> is the router's interface IP address. <i>port-number</i> identifies the UDP port on which the Director is listening for alarms (45000 is the default). <i>preference-number</i> is the relative priority of the route to the Director (1 is the default)—if more than one route is used to reach the same Director, then one must be a primary route (preference 1) and the other a secondary route (preference 2). <i>seconds</i> is the number of seconds the Post Office waits before it determines that a connection has timed out (5 is the default). <i>application-type</i> is either director or logger. <p>Note If you are sending Post Office notifications to a Sensor, use logger instead of director as your application. Sending to a logging application means that no alarms are sent to a GUI; instead, the Cisco Secure IDS alarm data is written to a flat file, which can then be processed with filters, such as perl and awk, or staged to a database. Use logger only in advanced applications where you want the alarms only to be logged and not displayed.</p>
Step 4	Router(config)# logging console info	Displays the syslog messages on the router console if you are sending alarms to the syslog console.
Step 5	Router(config)# exit	Exits global configuration mode.
Step 6	Router# write memory	Saves the configuration.
Step 7	Router# reload	Reloads the router.

After you have configured the router, add the Cisco IOS Firewall IDS router's Post Office information to the */usr/nr/etc/hosts* and */usr/nr/etc/routes* files on the Cisco Secure IDS Sensors and Directors communicating with the router. You can do this with the nrConfigure tool in Cisco Secure IDS. For more information, refer to the *NetRanger User Guide*.

Configuring and Applying Audit Rules

To configure and apply audit rules, use the following commands starting in global configuration mode:

	Command	Purpose
Step 1	<pre>Router(config)# ip audit info {action [alarm] [drop] [reset]}</pre> <p>and</p> <pre>Router(config)# ip audit attack {action [alarm] [drop] [reset]}</pre>	Sets the default actions for info and attack signatures. Both types of signatures can take any or all of the following actions: alarm, drop, and reset. The default action is alarm .
Step 2	<pre>Router(config)# ip audit name audit-name {info attack} [list standard-acl] [action [alarm] [drop] [reset]]</pre>	<p>Creates audit rules, where <i>audit-name</i> is a user-defined name for an audit rule. For example:</p> <pre>ip audit name audit-name info ip audit name audit-name attack</pre> <p>The default action is alarm.</p> <p>Note Use the same name when you assign attack and info type signatures.</p> <p>You can also use the ip audit name command to attach access control lists to an audit rule for filtering out sources of false alarms. In this case <i>standard-acl</i> is an integer representing an ACL. If you attach an ACL to an audit rule, the ACL must be defined as well:</p> <pre>ip audit name audit-name {info attack} list acl-list</pre> <p>In the following example, ACL 99 is attached to the audit rule INFO, and ACL 99 is defined:</p> <pre>ip audit name INFO info list 99 access-list 99 deny 10.1.1.0 0.0.0.255 access-list 99 permit any</pre> <p>Note The ACL in the preceding example is <i>not</i> denying traffic from the 10.1.1.0 network (as expected if it were applied to an interface). Instead, the hosts on that network are not filtered through the audit process because they are trusted hosts. On the other hand, all other hosts, as defined by permit any, are processed by the audit rule.</p>

	Command	Purpose
Step 3	Router(config)# ip audit signature signature-id { disable list acl-list}	<p>Disables individual signatures. Disabled signatures are not included in audit rules, as this is a global configuration change:</p> <pre>ip audit signature signature-number disable</pre> <p>To re-enable a disabled signature, use the no ip audit signature command, where <i>signature-number</i> is the number of the disabled signature.</p> <p>You can also use the ip audit signature command to apply ACLs to individual signatures for filtering out sources of false alarms. In this case <i>signature-number</i> is the number of a signature, and <i>acl-list</i> is an integer representing an ACL:</p> <pre>ip audit signature signature-number list acl-list</pre> <p>For example, ACL 35 is attached to the 1234 signature, and then defined:</p> <pre>ip audit signature 1234 list 35 access-list 35 deny 10.1.1.0 0.0.0.255 access-list 35 permit any</pre> <p>Note The ACL in the preceding example is <i>not</i> denying traffic from the 10.1.1.0 network (as expected if it were applied to an interface). Instead, the hosts on that network are not filtered through the signature because they are trusted hosts or are otherwise causing false positives to occur. On the other hand, all other hosts, as defined by permit any, are processed by the signature.</p>
Step 4	Router(config-if)# interface interface-number	Enters interface configuration mode.
Step 5	Router(config-if)# ip audit audit-name { in out }	Applies an audit rule at an interface. With this command, <i>audit-name</i> is the name of an existing audit rule, and <i>direction</i> is either in or out .
Step 6	Router(config-if)# exit	Exits interface configuration mode.
Step 7	Router(config)# ip audit po protected ip-addr [to ip-addr]	Configures which network should be protected by the router. Here, <i>ip_addr</i> is the IP address to protect.
Step 8	Router(config)# exit	Exits global configuration mode.

Verifying the Configuration

You can verify that Cisco IOS Firewall IDS is properly configured with the **show ip audit configuration** command (see [Example 1](#)).

Example 1 Output from show ip audit configuration Command

```
ids2611# show ip audit configuration

Event notification through syslog is enabled
Event notification through Net Director is enabled
Default action(s) for info signatures is alarm
Default action(s) for attack signatures is alarm drop reset
Default threshold of recipients for spam signature is 25
PostOffice:HostID:55 OrgID:123 Msg dropped:0
      :Curr Event Buf Size:100 Configured:100
HID:14 OID:123 S:1 A:2 H:82 HA:49 DA:0 R:0 Q:0
  ID:1 Dest:10.1.1.99:45000 Loc:172.16.58.99:45000 T:5 S:ESTAB *

Audit Rule Configuration
Audit name AUDIT.1
  info actions alarm
  attack actions alarm drop reset
```

You can verify which interfaces have audit rules applied to them with the **show ip audit interface** command (see [Example 2](#)).

Example 2 Output from show ip audit interface Command

```
ids2611# show ip audit interface

Interface Configuration
Interface Ethernet0
  Inbound IDS audit rule is AUDIT.1
  info actions alarm
  attack actions alarm drop reset
  Outgoing IDS audit rule is not set
Interface Ethernet1
  Inbound IDS audit rule is AUDIT.1
  info actions alarm
  attack actions alarm drop reset
  Outgoing IDS audit rule is not set
```

Monitoring and Maintaining Cisco IOS Firewall IDS

This section describes the EXEC commands used to monitor and maintain Cisco IOS Firewall IDS.

Command	Purpose
Router# clear ip audit configuration	Disables Cisco IOS Firewall IDS, removes all intrusion detection configuration entries, and releases dynamic resources.
Router# clear ip audit statistics	Resets statistics on packets analyzed and alarms sent.
Router# show ip audit statistics	Displays the number of packets audited and the number of alarms sent, among other information.

The following display provides sample output from the **show ip audit statistics** command:

```
Signature audit statistics [process switch:fast switch]
signature 2000 packets audited: [0:2]
signature 2001 packets audited: [9:9]
signature 2004 packets audited: [0:2]
signature 3151 packets audited: [0:12]
Interfaces configured for audit 2
Session creations since subsystem startup or last reset 11
Current session counts (estab/half-open/terminating) [0:0:0]
Maxever session counts (estab/half-open/terminating) [2:1:0]
Last session created 19:18:27
Last statistic reset never
```

```
HID:1000 OID:100 S:218 A:3 H:14085 HA:7114 DA:0 R:0
```

Cisco IOS Firewall IDS Configuration Examples

The following sections provide Cisco IOS Firewall IDS configuration examples:

- [Cisco IOS Firewall IDS Reporting to Two Directors Example](#)
- [Adding an ACL to the Audit Rule Example](#)
- [Disabling a Signature Example](#)
- [Adding an ACL to Signatures Example](#)
- [Dual-Tier Signature Response Example](#)

Cisco IOS Firewall IDS Reporting to Two Directors Example

In the following example, Cisco IOS Firewall IDS is initialized. Notice that the router is reporting to two Directors. Also notice that the AUDIT.1 audit rule will apply both info and attack signatures.

```
ip audit smtp spam 25
ip audit notify nr-director
ip audit notify log
ip audit po local hostid 55 orgid 123
ip audit po remote hostid 14 orgid 123 rmtaddress 10.1.1.99 localaddress 10.1.1.1
ip audit po remote hostid 15 orgid 123 rmtaddress 10.1.2.99 localaddress 10.1.1.1

ip audit name AUDIT.1 info action alarm
ip audit name AUDIT.1 attack action alarm drop reset

interface e0
 ip address 10.1.1.1 255.0.0.0
 ip audit AUDIT.1 in

interface e1
 ip address 172.16.57.1 255.255.255.0
 ip audit AUDIT.1 in
```


Adding an ACL to the Audit Rule Example

In the following example, an ACL is added to account for a Cisco Secure IDS Scanner (172.16.59.16) that scans for all types of attacks. As a result, no packets originating from the device will be audited.

```
ip audit smtp spam 25
ip audit notify nr-director
ip audit notify log
ip audit po local hostid 55 orgid 123
ip audit po remote hostid 14 orgid 123 rmtaddress 10.1.1.99 localaddress 10.1.1.1
ip audit po remote hostid 15 orgid 123 rmtaddress 10.1.2.99 localaddress 10.1.1.1

ip audit name AUDIT.1 info list 90 action alarm
ip audit name AUDIT.1 attack list 90 action alarm drop reset

interface e0
 ip address 10.1.1.1 255.0.0.0
 ip audit AUDIT.1 in

interface e1
 ip address 172.16.57.1 255.255.255.0
 ip audit AUDIT.1 in

access-list 90 deny 172.16.59.16
access-list 90 permit any
```

Disabling a Signature Example

The security administrator notices that the router is generating a lot of false positives for signatures 1234, 2345, and 3456. The system administrator knows that there is an application on the network that is causing signature 1234 to fire, and it is not an application that should cause security concerns. This signature can be disabled, as illustrated in the following example:

```
ip audit smtp spam 25
ip audit notify nr-director
ip audit notify log
ip audit po local hostid 55 orgid 123
ip audit po remote hostid 14 orgid 123 rmtaddress 10.1.1.99 localaddress 10.1.1.1
ip audit po remote hostid 15 orgid 123 rmtaddress 10.1.2.99 localaddress 10.1.1.1

ip audit signature 1234 disable

ip audit name AUDIT.1 info list 90 action alarm
ip audit name AUDIT.1 attack list 90 action alarm drop reset

interface e0
 ip address 10.1.1.1 255.0.0.0
 ip audit AUDIT.1 in

interface e1
 ip address 172.16.57.1 255.255.255.0
 ip audit AUDIT.1 in

access-list 90 deny 172.16.59.16
access-list 90 permit any
```

Adding an ACL to Signatures Example

After further investigation, the security administrator discovers that the false positives for signatures 2345 and 3456 are caused by specific applications on hosts 10.4.1.1 and 10.4.1.2, as well as by some workstations using DHCP on the 172.16.58.0 subnetwork. Attaching an ACL that denies processing of these hosts stops the creation of false positive alarms, as illustrated in the following example:

```
ip audit smtp spam 25
ip audit notify nr-director
ip audit notify log
ip audit po local hostid 55 orgid 123
ip audit po remote hostid 14 orgid 123 rmtaddress 10.1.1.99 localaddress 10.1.1.1
ip audit po remote hostid 15 orgid 123 rmtaddress 10.1.2.99 localaddress 10.1.1.1

ip audit signature 1234 disable
ip audit signature 2345 list 91
ip audit signature 3456 list 91

ip audit name AUDIT.1 info list 90 action alarm
ip audit name AUDIT.1 attack list 90 action alarm drop reset

interface e0
ip address 10.1.1.1 255.0.0.0
ip audit AUDIT.1 in

interface e1
ip address 172.16.57.1 255.255.255.0
ip audit AUDIT.1 in

access-list 90 deny 172.16.59.16
access-list 90 permit any
access-list 91 deny host 10.4.1.1
access-list 91 deny host 10.4.1.2
access-list 91 deny 172.16.58.0 0.0.0.255
access-list 91 permit any
```

Dual-Tier Signature Response Example

The company has now reorganized and has placed only trusted people on the 172.16.57.0 network. The work done by the employees on these networks must not be disrupted by Cisco IOS Firewall IDS, so attack signatures in the AUDIT.1 audit rule now will only alarm on a match.

For sessions that originate from the outside network, any attack signature matches (other than the false positive ones that are being filtered out) are to be dealt with in the following manner: send an alarm, drop the packet, and reset the TCP session.

This dual-tier method of signature response is accomplished by configuring two different audit specifications and applying each to a different ethernet interface, as illustrated in the following example:

```
ip audit smtp spam 25
ip audit notify nr-director
ip audit notify log
ip audit po local hostid 55 orgid 123
ip audit po remote hostid 14 orgid 123 rmtaddress 10.1.1.99 localaddress 10.1.1.1
ip audit po remote hostid 15 orgid 123 rmtaddress 10.1.2.99 localaddress 10.1.1.1

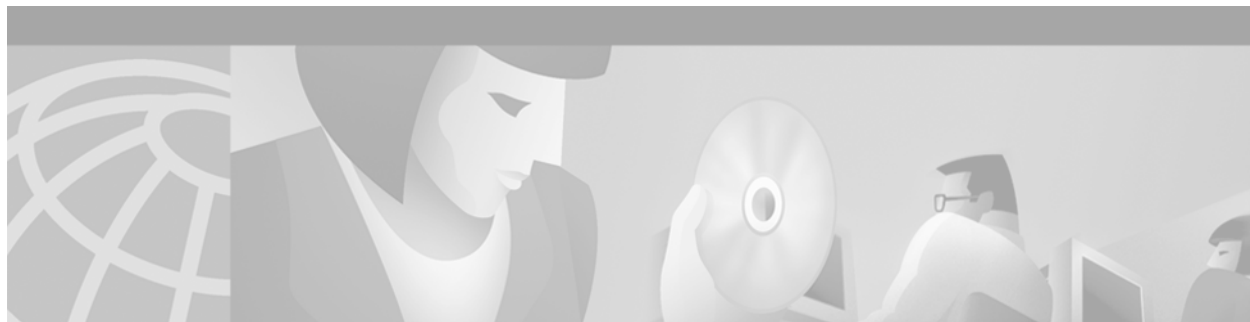
ip audit signature 1234 disable
ip audit signature 2345 list 91
ip audit signature 3456 list 91
```

```
ip audit name AUDIT.1 info list 90 action alarm
ip audit name AUDIT.1 attack list 90 action alarm
ip audit name AUDIT.2 info action alarm
ip audit name AUDIT.2 attack alarm drop reset

interface e0
  ip address 10.1.1.1 255.0.0.0
  ip audit AUDIT.2 in

interface e1
  ip address 172.16.57.1 255.255.255.0
  ip audit AUDIT.1 in

access-list 90 deny host 172.16.59.16
access-list 90 permit any
access-list 91 deny host 10.4.1.1
access-list 91 deny host 10.4.1.2
access-list 91 deny 172.16.58.0 0.0.0.255
access-list 91 permit any
```

IP Security and Encryption Overview

This chapter briefly describes the following security features and how they relate to each other:

- [IPSec Network Security](#)
- [Certification Authority Interoperability](#)
- [Internet Key Exchange Security Protocol](#)

IPSec Network Security

IPSec is a framework of open standards developed by the Internet Engineering Task Force (IETF) that provides security for transmission of sensitive information over unprotected networks such as the Internet. It acts at the network level and implements the following standards:

- IPSec
- Internet Key Exchange (IKE)
- Data Encryption Standard (DES)
- MD5 (HMAC variant)
- SHA (HMAC variant)
- Authentication Header (AH)
- Encapsulating Security Payload (ESP)

IPSec services provide a robust security solution that is standards-based. IPSec also provides data authentication and anti-replay services in addition to data confidentiality services.

For more information regarding IPSec, refer to the chapter “[Configuring IPSec Network Security](#).”

IPSec Encryption Technology

IPSec protects sensitive data that travels across unprotected networks. IPSec security services are provided at the network layer, so you do not have to configure individual workstations, PCs, or applications. This benefit can provide a great cost savings. Instead of providing the security services you do not need to deploy and coordinate security on a per-application, per-computer basis, you can simply change the network infrastructure to provide the needed security services.

IPSec encryption offers a number of additional benefits:

- Because IPSec is standards-based, enables Cisco devices to interoperate with other IPSec-compliant networking devices to provide the IPSec security services. IPSec-compliant devices could include both Cisco devices and non-Cisco devices such as PCs, servers, and other computing systems.
Cisco and its partners, including Microsoft, are planning to offer IPSec across a wide range of platforms, including Cisco IOS software, the Cisco PIX Firewall, and Windows 2000.
- Enables a mobile user to establish a secure connection back to the office. For example, the user can establish an IPSec “tunnel” with a corporate firewall—requesting authentication services—in order to gain access to the corporate network; all of the traffic between the user and the firewall will then be authenticated. The user can then establish an additional IPSec tunnel—requesting data privacy services—with an internal router or end system.
- Provides support for the Internet Key Exchange (IKE) protocol and for digital certificates. IKE provides negotiation services and key derivation services for IPSec. Digital certificates allow devices to be automatically authenticated to each other without manual key exchanges.

Certification Authority Interoperability

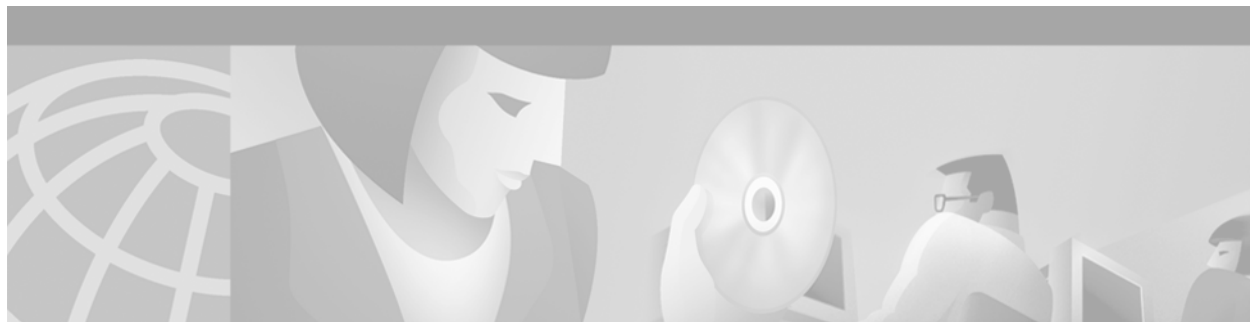
Certification Authority (CA) interoperability is provided in support of the IPSec standard. It permits Cisco IOS devices and CAs to communicate so that your Cisco IOS device can obtain and use digital certificates from the CA. Although IPSec can be implemented in your network without the use of a CA, using a CA provides manageability and scalability for IPSec.

For more information regarding CA interoperability, refer to the chapter “Configuring Certification Authority Interoperability.”

Internet Key Exchange Security Protocol

Internet Key Exchange (IKE) security protocol is a key management protocol standard that is used in conjunction with the IPSec standard. IPSec can be configured without IKE, but IKE enhances IPSec by providing additional features, flexibility, and ease of configuration for the IPSec standard.

For more information regarding IKE, refer to the chapter “[Configuring Internet Key Exchange Security Protocol](#).”



Configuring IPSec Network Security

This chapter describes how to configure IPSec, which is a framework of open standards developed by the Internet Engineering Task Force (IETF). IPSec provides security for transmission of sensitive information over unprotected networks such as the Internet. IPSec acts at the network layer, protecting and authenticating IP packets between participating IPSec devices (“peers”), such as Cisco routers.

IPSec provides the following network security services. These services are optional. In general, local security policy will dictate the use of one or more of these services:

- Data Confidentiality—The IPSec sender can encrypt packets before transmitting them across a network.
- Data Integrity—The IPSec receiver can authenticate packets sent by the IPSec sender to ensure that the data has not been altered during transmission.
- Data Origin Authentication—The IPSec receiver can authenticate the source of the IPSec packets sent. This service is dependent upon the data integrity service.
- Anti-Replay—The IPSec receiver can detect and reject replayed packets.



Note

The term *data authentication* is generally used to mean data integrity and data origin authentication. Within this chapter it also includes anti-replay services, unless otherwise specified.

With IPSec, data can be transmitted across a public network without fear of observation, modification, or spoofing. This enables applications such as Virtual Private Networks (VPNs), including intranets, extranets, and remote user access.

For a complete description of the IPSec Network Security commands used in this chapter, refer to the “IPSec Network Security Commands” chapter in the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the “Identifying Supported Platforms” section in the chapter “Using Cisco IOS Software.”

In This Chapter

This chapter has the following sections:

- [About IPSec](#)
- [IPSec Configuration Task List](#)
- [IPSec Configuration Example](#)

About IPSec

IPSec provides network data encryption at the IP packet level, offering a robust security solution that is standards-based. IPSec provides data authentication and anti-replay services in addition to data confidentiality services.

This section has the following sections:

- [Supported Standards](#)
- [List of Terms](#)
- [Supported Hardware, Switching Paths, and Encapsulation](#)
- [Restrictions](#)
- [Overview of How IPSec Works](#)
- [Nesting of IPSec Traffic to Multiple Peers](#)
- [Prerequisites](#)

Supported Standards

Cisco implements the following standards with this feature:

- **IPSec**—IP Security Protocol. IPSec is a framework of open standards that provides data confidentiality, data integrity, and data authentication between participating peers. IPSec provides these security services at the IP layer; it uses IKE to handle negotiation of protocols and algorithms based on local policy, and to generate the encryption and authentication keys to be used by IPSec. IPSec can be used to protect one or more data flows between a pair of hosts, between a pair of security gateways, or between a security gateway and a host.

**Note**

The term IPSec is sometimes used to describe the entire protocol of IPSec data services and IKE security protocols and is also sometimes used to describe only the data services.

IPSec is documented in a series of Internet Drafts, all available at <http://www.ietf.org/html.charters/ipsec-charter.html>. The overall IPSec implementation is per the latest version of the *Security Architecture for the Internet Protocol* Internet Draft (RFC2401). Cisco IOS IPSec implements RFC 2402 (*IP Authentication Header*) though RFC 2410 (*The NULL Encryption Algorithm and Its Use With IPSec*).

- **Internet Key Exchange (IKE)**—A hybrid protocol that implements Oakley and SKEME key exchanges inside the ISAKMP framework. While IKE can be used with other protocols, its initial implementation is with the IPSec protocol. IKE provides authentication of the IPSec peers, negotiates IPSec security associations, and establishes IPSec keys.

For more information on IKE, see the chapter “Configuring Internet Key Exchange Security Protocol.”

The component technologies implemented for IPsec include:

- **DES**—The Data Encryption Standard (DES) is used to encrypt packet data. Cisco IOS implements the mandatory 56-bit DES-CBC with Explicit IV. Cipher Block Chaining (CBC) requires an initialization vector (IV) to start encryption. The IV is explicitly given in the IPsec packet. For backwards compatibility, Cisco IOS IPsec also implements the RFC 1829 version of ESP DES-CBC.

Cisco IOS also implements Triple DES (168-bit) encryption, depending on the software versions available for a specific platform. Triple DES (3DES) is a strong form of encryption that allows sensitive information to be transmitted over untrusted networks. It enables customers to utilize network layer encryption.

**Note**

Cisco IOS images with strong encryption (including, but not limited to, 56-bit data encryption feature sets) are subject to United States government export controls, and have a limited distribution. Images to be installed outside the United States require an export license. Customer orders might be denied or subject to delay due to United States government regulations. Contact your sales representative or distributor for more information, or send e-mail to export@cisco.com.

- **MD5 (HMAC variant)**—MD5 (Message Digest 5) is a hash algorithm. HMAC is a keyed hash variant used to authenticate data.
- **SHA (HMAC variant)**—SHA (Secure Hash Algorithm) is a hash algorithm. HMAC is a keyed hash variant used to authenticate data.

IPsec as implemented in Cisco IOS software supports the following additional standards:

- **AH**—Authentication Header. A security protocol which provides data authentication and optional anti-replay services. AH is embedded in the data to be protected (a full IP datagram).
- **ESP**—Encapsulating Security Payload. A security protocol which provides data privacy services and optional data authentication, and anti-replay services. ESP encapsulates the data to be protected.

List of Terms

Anti-Replay

Anti-replay is a security service where the receiver can reject old or duplicate packets in order to protect itself against replay attacks. IPsec provides this optional service by use of a sequence number combined with the use of data authentication. Cisco IOS IPsec provides this service whenever it provides the data authentication service, except in the following cases:

The service is not available for manually established security associations (that is, security associations established by configuration and not by IKE).

Data Authentication

Data Authentication includes two concepts:

- Data integrity (verify that data has not been altered).
- Data origin authentication (verify that the data was actually sent by the claimed sender).

Data authentication can refer either to integrity alone or to both of these concepts (although data origin authentication is dependent upon data integrity).

Data Confidentiality

Data confidentiality is a security service where the protected data cannot be observed.

Data Flow

Data flow is a grouping of traffic, identified by a combination of source address/mask, destination address/mask, IP next protocol field, and source and destination ports, where the protocol and port fields can have the values of **any**. In effect, all traffic matching a specific combination of these values is logically grouped together into a data flow. A data flow can represent a single TCP connection between two hosts, or it can represent all of the traffic between two subnets. IPSec protection is applied to data flows.

Peer

In the context of this chapter, “peer” refers to a router or other device that participates in IPSec.

Perfect Forward Secrecy (PFS)

Perfect forward secrecy is a cryptographic characteristic associated with a derived shared secret value. With PFS, if one key is compromised, previous and subsequent keys are not compromised, because subsequent keys are not derived from previous keys.

Security Association

Security association is a description of how two or more entities will use security services in the context of a particular security protocol (AH or ESP) to communicate securely on behalf of a particular data flow. It includes such things as the transform and the shared secret keys to be used for protecting the traffic.

The IPSec security association is established either by IKE or by manual user configuration. Security associations are unidirectional and are unique per security protocol. So when security associations are established for IPSec, the security associations (for each protocol) for both directions are established at the same time.

When using IKE to establish the security associations for the data flow, the security associations are established when needed and expire after a period of time (or volume of traffic). If the security associations are manually established, they are established as soon as the necessary configuration is completed and do not expire.

Security Parameter Index (SPI)

Security parameter index is a number which, together with a destination IP address and security protocol, uniquely identifies a particular security association. When using IKE to establish the security associations, the SPI for each security association is a pseudo-randomly derived number. Without IKE, the SPI is manually specified for each security association.

Transform

Transform is the list of operations done on a dataflow to provide data authentication, data confidentiality, and data compression. For example, one transform is the ESP protocol with the HMAC-MD5 authentication algorithm; another transform is the AH protocol with the 56-bit DES encryption algorithm and the ESP protocol with the HMAC-SHA authentication algorithm.

Tunnel

In the context of this chapter, “tunnel” is a secure communication path between two peers, such as two routers. It does not refer to using IPSec in tunnel mode.

Supported Hardware, Switching Paths, and Encapsulation

IPsec has certain restrictions for hardware, switching paths, and encapsulation methods as follows:

Supported Hardware

ISA and ISM Support

For 7100 and 7200 hardware platforms, IPsec support requires the following adaptors or modules:

- Integrated Services Adapter (ISA) for the Cisco 7100 and 7200 series.
- Integrated Services Modules (ISM) for the Cisco 7100 series.



Note A VPN accelerator card and controller is also available on a Cisco 7100 and a Cisco 7200 series routers with an ISA and a Cisco 7100 series router with and ISM.

For more information on ISAs and ISMs, refer to the *Integrated Services Adapter and Integrated Services Module Installation and Configuration* publication.

VPN Module Support

For 1720 and 1750 hardware platforms, the VPN module assists the host processor by accelerating layer 3 IPsec data and voice encryption and decryption. The VPN module supports DES and 3DES encryption algorithms, MD5 and SHA-1 hashing, and Diffie-Hellman key generation.

The VPN module encrypts data using DES and Triple DES algorithms at speeds suitable for full duplex T1/E1 serial connections (4 megabits per second for 1518-byte packets). Equipped with a VPN module, a Cisco 1700 router supports up to 100 secure IPsec tunnels.

For more information on VPNs, refer to the chapter “Configuring Virtual Private Networks” in *Cisco IOS Dial Technologies Configuration Guide*.

AIMs and NM Support

For Cisco 2600 and Cisco 3600 series routers, the data encryption Advanced Integration Module (AIM) and Network Module (NM) provide hardware-based encryption. These data encryption products require Cisco IOS Release 12.1(3)XI or later.

The data encryption AIMs and NM are hardware Layer 3 (IPsec) encryption modules and provide DES and Triple DES IPsec encryption for multiple T1s or E1s of bandwidth. These products also have hardware support for Diffie-Hellman, RSA, and DSA key generation.

For more information on AIMs and NM, refer to *Installing the Data Encryption AIM in Cisco 2600 Series and Cisco 3600 Series Routers*.

Supported Switching Paths

[Table 24](#) lists the supported switching paths that work with IPsec.

Table 24 Supported Switching Paths for IPSec

Switching Paths	Examples
Process switching	<pre>interface ethernet0/0 no ip route-cache</pre>
Fast switching	<pre>interface ethernet0/0 ip route-cache ! Ensure that you will not hit flow switching. no ip route-cache flow ! Disable CEF for the interface, which supercedes global CEF. no ip route-cache cef</pre>
Cisco Express Forwarding (CEF)	<pre>ip cef interface ethernet0/0 ip route-cache ! Ensure that you will not hit flow switching. no ip route-cache flow</pre>
Fast-flow switching	<pre>interface ethernet0/0 ip route-cache ! Enable flow switching ip route-cache flow ! Disable CEF for the interface. no ip route-cache cef</pre>
CEF-flow switching	<pre>! Enable global CEF. ip cef interface ethernet0/0 ip route-cache ip route-cache flow ! Enable CEF for the interface ip route-cache cef</pre>

For more information on the supported switching paths, see the *Cisco IOS Switching Services Configuration Guide*, Release 12.2.

Supported Encapsulation

IPSec works with the following serial encapsulations: High-Level Data-Links Control (HDLC), Point-to-Point Protocol (PPP), and Frame Relay.

IPSec also works with the GRE and IPinIP Layer 3, L2F, L2TP, DLSw+, and SRB tunneling protocols; however, multipoint tunnels are not supported. Other Layer 3 tunneling protocols may not be supported for use with IPSec.

Because the IPSec Working Group has not yet addressed the issue of group key distribution, IPSec currently cannot be used to protect group traffic (such as broadcast or multicast traffic).

Restrictions

At this time, IPSec can be applied to unicast IP datagrams only. Because the IPSec Working Group has not yet addressed the issue of group key distribution, IPSec does not currently work with multicasts or broadcast IP datagrams.

If you use Network Address Translation (NAT), you should configure static NAT translations so that IPsec will work properly. In general, NAT translation should occur before the router performs IPsec encapsulation; in other words, IPsec should be working with global addresses.

Overview of How IPsec Works

In simple terms, IPsec provides secure *tunnels* between two peers, such as two routers. You define which packets are considered sensitive and should be sent through these secure tunnels, and you define the parameters which should be used to protect these sensitive packets, by specifying characteristics of these tunnels. Then, when the IPsec peer sees such a sensitive packet, it sets up the appropriate secure tunnel and sends the packet through the tunnel to the remote peer.



Note

The use of the term *tunnel* in this chapter does not refer to using IPsec in tunnel mode.

More accurately, these *tunnels* are sets of security associations that are established between two IPsec peers. The security associations define which protocols and algorithms should be applied to sensitive packets, and also specify the keying material to be used by the two peers. Security associations are unidirectional and are established per security protocol (AH or ESP).

With IPsec you define what traffic should be protected between two IPsec peers by configuring access lists and applying these access lists to interfaces by way of crypto map sets. Therefore, traffic may be selected based on source and destination address, and optionally Layer 4 protocol, and port. (The access lists used for IPsec are used only to determine which traffic should be protected by IPsec, not which traffic should be blocked or permitted through the interface. Separate access lists define blocking and permitting at the interface.)

A crypto map set can contain multiple entries, each with a different access list. The crypto map entries are searched in order—the router attempts to match the packet to the access list specified in that entry.

When a packet matches a **permit** entry in a particular access list, and the corresponding crypto map entry is tagged as **cisco**, and connections are established if necessary. If the crypto map entry is tagged as **ipsec-isakmp**, IPsec is triggered. If no security association exists that IPsec can use to protect this traffic to the peer, IPsec uses IKE to negotiate with the remote peer to set up the necessary IPsec security associations on behalf of the data flow. The negotiation uses information specified in the crypto map entry as well as the data flow information from the specific access list entry. (The behavior is different for dynamic crypto map entries. Refer to the “[Creating Dynamic Crypto Maps](#)” section later in this chapter.)

If the crypto map entry is tagged as **ipsec-manual**, IPsec is triggered. If no security association exists that IPsec can use to protect this traffic to the peer, the traffic is dropped. In this case, the security associations are installed via the configuration, without the intervention of IKE. If the security associations did not exist, IPsec did not have all of the necessary pieces configured.

Once established, the set of security associations (outbound, to the peer) is then applied to the triggering packet as well as to subsequent applicable packets as those packets exit the router. “Applicable” packets are packets that match the same access list criteria that the original packet matched. For example, all applicable packets could be encrypted before being forwarded to the remote peer. The corresponding inbound security associations are used when processing the incoming traffic from that peer.

If IKE is used to establish the security associations, the security associations will have lifetimes so that they will periodically expire and require renegotiation. (This provides an additional level of security.)

Multiple IPsec tunnels can exist between two peers to secure different data streams, with each tunnel using a separate set of security associations. For example, some data streams might be just authenticated while other data streams must both be encrypted and authenticated.

Access lists associated with IPsec crypto map entries also represent which traffic the router requires to be protected by IPsec. Inbound traffic is processed against the crypto map entries—if an unprotected packet matches a **permit** entry in a particular access list associated with an IPsec crypto map entry, that packet is dropped because it was not sent as an IPsec-protected packet.

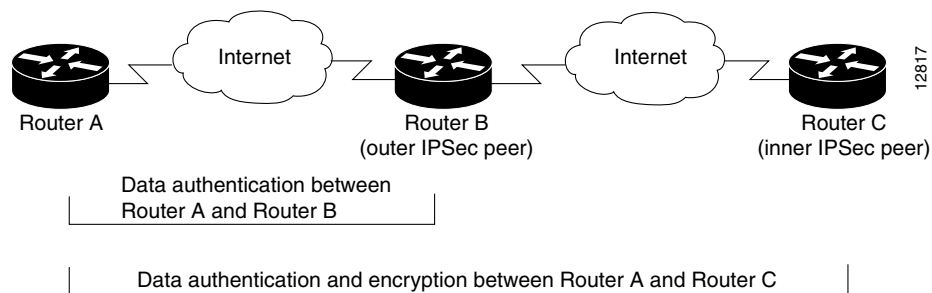
Crypto map entries also include transform sets. A transform set is an acceptable combination of security protocols, algorithms and other settings to apply to IPsec protected traffic. During the IPsec security association negotiation, the peers agree to use a particular transform set when protecting a particular data flow.

Nesting of IPsec Traffic to Multiple Peers

You can nest IPsec traffic to a series of IPsec peers. For example, in order for traffic to traverse multiple firewalls (and these firewalls have a policy of not letting through traffic that they themselves have not authenticated), the router needs to establish IPsec tunnels with each firewall in turn. The “nearest” firewall becomes the “outermost” IPsec peer.

In the example shown in [Figure 30](#), Router A encapsulates the traffic destined for Router C in IPsec (Router C is the IPsec peer). However, before Router A can send this traffic, it must first reencapsulate this traffic in IPsec in order to send it to Router B (Router B is the “outermost” IPsec peer).

Figure 30 Nesting Example of IPsec Peers



It is possible for the traffic between the “outer” peers to have one kind of protection (such as data authentication) and for traffic between the “inner” peers to have different protection (such as both data authentication and encryption).

Prerequisites

You must configure IKE as described in the “Configuring Internet Key Exchange Security Protocol” chapter.

Even if you decide to not use IKE, you still must disable it as described in the chapter “Configuring Internet Key Exchange Security Protocol.”

IPsec Configuration Task List

- [Ensuring That Access Lists Are Compatible with IPsec](#)
- [Setting Global Lifetimes for IPsec Security Associations](#)

- [Creating Crypto Access Lists](#)
- [Defining Transform Sets](#)
- [Creating Crypto Map Entries](#)
- [Applying Crypto Map Sets to Interfaces](#)
- [Monitoring and Maintaining IPsec](#)

For IPsec configuration examples, refer to the “[IPsec Configuration Example](#)” section at the end of this chapter.

Ensuring That Access Lists Are Compatible with IPsec

IKE uses UDP port 500. The IPsec ESP and AH protocols use protocol numbers 50 and 51. Ensure that your access lists are configured so that protocol 50, 51, and UDP port 500 traffic is not blocked at interfaces used by IPsec. In some cases you might need to add a statement to your access lists to explicitly permit this traffic.

Setting Global Lifetimes for IPsec Security Associations

You can change the global lifetime values which are used when negotiating new IPsec security associations. (These global lifetime values can be overridden for a particular crypto map entry).

These lifetimes only apply to security associations established via IKE. Manually established security associations do not expire.

There are two lifetimes: a “timed” lifetime and a “traffic-volume” lifetime. A security association expires after the first of these lifetimes is reached. The default lifetimes are 3600 seconds (one hour) and 4,608,000 kilobytes (10 megabits per second for one hour per second for one hour).

If you change a global lifetime, the new lifetime value will not be applied to currently existing security associations, but will be used in the negotiation of subsequently established security associations. If you wish to use the new values immediately, you can clear all or part of the security association database. Refer to the **clear crypto sa** command for more details.

IPsec security associations use one or more shared secret keys. These keys and their security associations time out together.

To change a global lifetime for IPsec security associations, use one or more of the following commands in global configuration mode:

Command	Purpose
Router(config)# crypto ipsec security-association lifetime seconds <i>seconds</i>	Changes the global “timed” lifetime for IPsec SAs. This command causes the security association to time out after the specified number of seconds have passed.

Command	Purpose
Router(config)# crypto ipsec security-association lifetime kilobytes <i>kilobytes</i>	Changes the global “traffic-volume” lifetime for IPSec SAs. This command causes the security association to time out after the specified amount of traffic (in kilobytes) have passed through the IPSec “tunnel” using the security association.
Router(config)# clear crypto sa or Router(config)# clear crypto sa peer { <i>ip-address</i> <i>peer-name</i> } or Router(config)# clear crypto sa map <i>map-name</i> or Router (config)# clear crypto sa entry <i>destination-address protocol spi</i>	(Optional) Clears existing security associations. This causes any existing security associations to expire immediately; future security associations will use the new lifetimes. Otherwise, any existing security associations will expire according to the previously configured lifetimes. Note Using the clear crypto sa command without parameters will clear out the full SA database, which will clear out active security sessions. You may also specify the peer , map , or entry keywords to clear out only a subset of the SA database. For more information, see the clear crypto sa command.

How These Lifetimes Work

Assuming that the particular crypto map entry does not have lifetime values configured, when the router requests new security associations it will specify its global lifetime values in the request to the peer; it will use this value as the lifetime of the new security associations. When the router receives a negotiation request from the peer, it will use the smaller of either the lifetime value proposed by the peer or the locally configured lifetime value as the lifetime of the new security associations.

The security association (and corresponding keys) will expire according to whichever comes sooner, either after the number of seconds has passed (specified by the **seconds** keyword) or after the amount of traffic in kilobytes is passed (specified by the **kilobytes** keyword). Security associations that are established manually (via a crypto map entry marked as **ipsec-manual**) have an infinite lifetime.

A new security association is negotiated *before* the lifetime threshold of the existing security association is reached, to ensure that a new security association is ready for use when the old one expires. The new security association is negotiated either 30 seconds before the **seconds** lifetime expires or when the volume of traffic through the tunnel reaches 256 kilobytes less than the **kilobytes** lifetime (whichever comes first).

If no traffic has passed through the tunnel during the entire life of the security association, a new security association is not negotiated when the lifetime expires. Instead, a new security association will be negotiated only when IPSec sees another packet that should be protected.

Creating Crypto Access Lists

Crypto access lists are used to define which IP traffic will be protected by crypto and which traffic will not be protected by crypto. (These access lists are *not* the same as regular access lists, which determine what traffic to forward or block at an interface.) For example, access lists can be created to protect all IP traffic between Subnet A and Subnet Y or Telnet traffic between Host A and Host B.

The access lists themselves are not specific to IPSec. It is the crypto map entry referencing the specific access list that defines whether IPSec processing is applied to the traffic matching a **permit** in the access list.

Crypto access lists associated with IPsec crypto map entries have four primary functions:

- Select outbound traffic to be protected by IPsec (permit = protect).
- Indicate the data flow to be protected by the new security associations (specified by a single **permit** entry) when initiating negotiations for IPsec security associations.
- Process inbound traffic in order to filter out and discard traffic that should have been protected by IPsec.
- Determine whether or not to accept requests for IPsec security associations on behalf of the requested data flows when processing IKE negotiation from the IPsec peer. (Negotiation is only done for **ipsec-isakmp** crypto map entries.) In order to be accepted, if the peer initiates the IPsec negotiation, it must specify a data flow that is “permitted” by a crypto access list associated with an **ipsec-isakmp** crypto map entry.

If you want certain traffic to receive one combination of IPsec protection (for example, authentication only) and other traffic to receive a different combination of IPsec protection (for example, both authentication and encryption), you need to create two different crypto access lists to define the two different types of traffic. These different access lists are then used in different crypto map entries which specify different IPsec policies.

Later, you will associate the crypto access lists to particular interfaces when you configure and apply crypto map sets to the interfaces (following instructions in the sections “[Creating Crypto Map Entries](#)” and “[Applying Crypto Map Sets to Interfaces](#)”).

To create crypto access lists, use the following command in global configuration mode:

Command	Purpose
Router(config)# access-list <i>access-list-number</i> { deny permit } <i>protocol source source-wildcard destination destination-wildcard</i> [log]	Specifies conditions to determine which IP packets will be protected. ¹ (Enable or disable crypto for traffic that matches these conditions.)
or	
Router(config)# ip access-list extended <i>name</i>	Configure “mirror image” crypto access lists for use by IPsec and avoid using the any keyword, as described in the sections “ Defining Mirror Image Crypto Access Lists at Each IPsec Peer ” and “ Using the any Keyword in Crypto Access Lists ” (following).
Follow with permit and deny statements as appropriate.	Also see the “ Crypto Access List Tips ” section.

1. You specify conditions using an IP access list designated by either a number or a name. The **access-list** command designates a numbered extended access list; the **ip access-list extended** command designates a named access list.

This section contains the following sections:

- [Crypto Access List Tips](#)
- [Defining Mirror Image Crypto Access Lists at Each IPsec Peer](#)
- [Using the any Keyword in Crypto Access Lists](#)

Crypto Access List Tips

Using the **permit** keyword causes all IP traffic that matches the specified conditions to be protected by crypto, using the policy described by the corresponding crypto map entry. Using the **deny** keyword prevents traffic from being protected by crypto in the context of that particular crypto map entry. (In other words, it does not allow the policy as specified in this crypto map entry to be applied to this traffic.) If this traffic is denied in all of the crypto map entries for that interface, then the traffic is not protected by crypto.

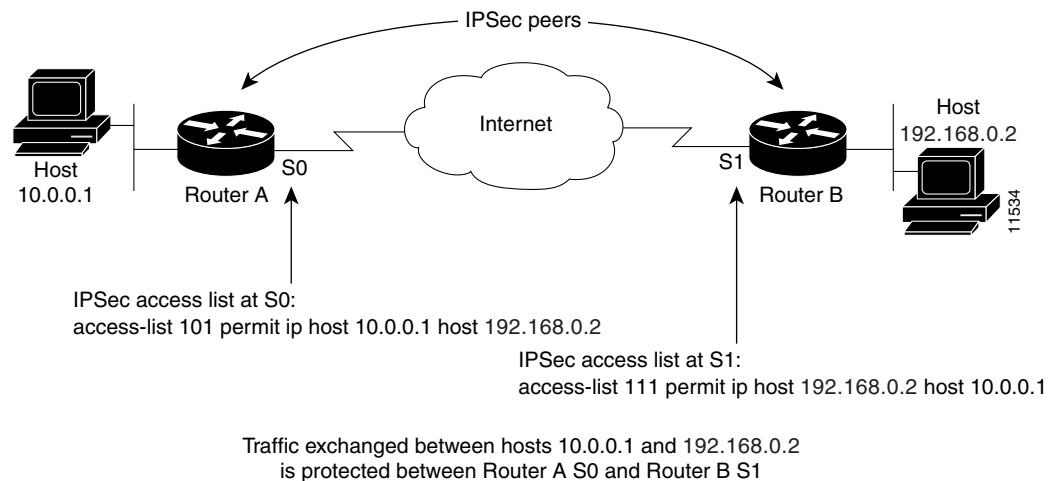
The crypto access list you define will be applied to an interface after you define the corresponding crypto map entry and apply the crypto map set to the interface. Different access lists must be used in different entries of the same crypto map set. (These two tasks are described in following sections.) However, both inbound and outbound traffic will be evaluated against the same “outbound” IPSec access list. Therefore, the access list’s criteria is applied in the forward direction to traffic exiting your router, and the reverse direction to traffic entering your router. In [Figure 31](#), IPSec protection is applied to traffic between Host 10.0.0.1 and Host 20.0.0.2 as the data exits Router A’s S0 interface en route to Host 20.0.0.2. For traffic from Host 10.0.0.1 to Host 20.0.0.2, the access list entry on Router A is evaluated as follows:

```
source = host 10.0.0.1
dest = host 20.0.0.2
```

For traffic from Host 20.0.0.2 to Host 10.0.0.1, that same access list entry on Router A is evaluated as follows:

```
source = host 20.0.0.2
dest = host 10.0.0.1
```

Figure 31 How Crypto Access Lists Are Applied for Processing IPSec



If you configure multiple statements for a given crypto access list which is used for IPSec, in general the first **permit** statement that is matched will be the statement used to determine the scope of the IPSec security association. That is, the IPSec security association will be set up to protect traffic that meets the criteria of the matched statement only. Later, if traffic matches a different **permit** statement of the crypto access list, a new, separate IPSec security association will be negotiated to protect traffic matching the newly matched access list statement.



Note

Access lists for crypto map entries tagged as **ipsec-manual** are restricted to a single **permit** entry and subsequent entries are ignored. In other words, the security associations established by that particular crypto map entry are only for a single data flow. To be able to support multiple manually established security associations for different kinds of traffic, define multiple crypto access lists, and then apply each one to a separate **ipsec-manual** crypto map entry. Each access list should include one **permit** statement defining what traffic to protect.

Any unprotected inbound traffic that matches a **permit** entry in the crypto access list for a crypto map entry flagged as IPSec will be dropped, because this traffic was expected to be protected by IPSec.

**Note**

If you view your router's access lists by using a command such as **show ip access-lists**, *all* extended IP access lists will be shown in the command output. This includes extended IP access lists that are used for traffic filtering purposes as well as those that are used for crypto. The **show** command output does not differentiate between the different uses of the extended access lists.

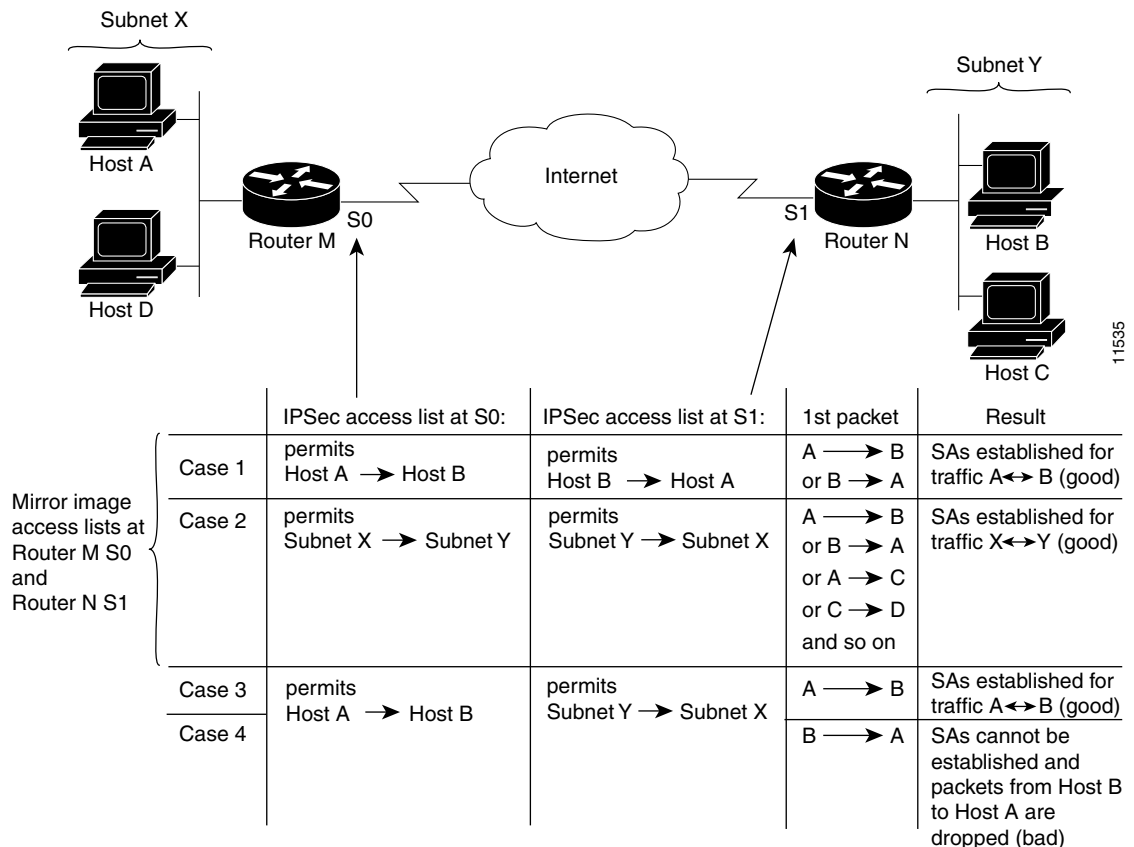
See the *Cisco IOS Security Command Reference* for complete details about the extended IP access list commands used to create IPsec access lists.

Defining Mirror Image Crypto Access Lists at Each IPsec Peer

For every crypto access list specified for a static crypto map entry that you define at the local peer, you must define a “mirror image” crypto access list at the remote peer. This ensures that traffic that has IPsec protection applied locally can be processed correctly at the remote peer. (The crypto map entries themselves must also support common transforms and must refer to the other system as a peer.)

Figure 32 shows some sample scenarios when you have mirror image access lists and when you do not have mirror image access lists.

Figure 32 Mirror Image vs. Non-Mirror Image Crypto Access Lists (for IPsec)



As Figure 32 indicates, IPsec Security Associations (SAs) can be established as expected whenever the two peers' crypto access lists are mirror images of each other. However, an IPsec SA can be established only some of the time when the access lists are not mirror images of each other. This can happen in the case where an entry in one peer's access list is a subset of an entry in the other peer's access list, such

as shown in Cases 3 and 4 of [Figure 32](#). IPsec SA establishment is critical to IPsec—without SAs, IPsec does not work, causing any packets matching the crypto access list criteria to be silently dropped instead of being forwarded with IPsec security.

In [Figure 32](#), an SA cannot be established in Case 4. This is because SAs are always requested according to the crypto access lists at the initiating packet's end. In Case 4, Router N requests that all traffic between Subnet X and Subnet Y be protected, but this is a superset of the specific flows permitted by the crypto access list at Router M so the request is therefore not permitted. Case 3 works because Router M's request is a subset of the specific flows permitted by the crypto access list at Router N.

Because of the complexities introduced when crypto access lists are not configured as mirror images at peer IPsec devices, Cisco strongly encourages you to use mirror image crypto access lists.

Using the any Keyword in Crypto Access Lists

When you create crypto access lists, using the **any** keyword could cause problems. Cisco discourages the use of the **any** keyword to specify source or destination addresses.

The **any** keyword in a **permit** statement is discouraged when you have multicast traffic flowing through the IPsec interface; the **any** keyword can cause multicast traffic to fail.

The **permit any any** statement is strongly discouraged, as this will cause all outbound traffic to be protected (and all protected traffic sent to the peer specified in the corresponding crypto map entry) and will require protection for all inbound traffic. Then, all inbound packets that lack IPsec protection will be silently dropped, including packets for routing protocols, NTP, echo, echo response, and so on.

You need to be sure you define which packets to protect. If you *must* use the **any** keyword in a **permit** statement, you must preface that statement with a series of **deny** statements to filter out any traffic (that would otherwise fall within that **permit** statement) that you do not want to be protected.

Defining Transform Sets

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

You can specify multiple transform sets, and then specify one or more of these transform sets in a crypto map entry. The transform set defined in the crypto map entry will be used in the IPsec security association negotiation to protect the data flows specified by that crypto map entry's access list.

During IPsec security association negotiations with IKE, the peers search for a transform set that is the same at both peers. When such a transform set is found, it is selected and will be applied to the protected traffic as part of both peers' IPsec security associations.

With manually established security associations, there is no negotiation with the peer, so both sides must specify the same transform set.

If you change a transform set definition, the change is only applied to crypto map entries that reference the transform set. The change will not be applied to existing security associations, but will be used in subsequent negotiations to establish new security associations. If you want the new settings to take effect sooner, you can clear all or part of the security association database by using the **clear crypto sa** command.

To define a transform set, use the following commands starting in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto ipsec transform-set <i>transform-set-name transform1 [transform2</i> <i>[transform3]]</i>	Defines a transform set. There are complex rules defining which entries you can use for the transform arguments. These rules are explained in the command description for the crypto ipsec transform-set command, and Table 25 provides a list of allowed transform combinations. This command puts you into the crypto transform configuration mode.
Step 2	Router(cfg-crypto-tran)# mode [tunnel transport]	(Optional) Changes the mode associated with the transform set. The mode setting is only applicable to traffic whose source and destination addresses are the IPsec peer addresses; it is ignored for all other traffic. (All other traffic is in tunnel mode only.)
Step 3	Router(cfg-crypto-tran)# exit	Exits the crypto transform configuration mode.
Step 4	Router(config)# clear crypto sa or Router(config)# clear crypto sa peer { <i>ip-address</i> <i>peer-name</i> } or Router(config)# clear crypto sa map <i>map-name</i> or Router(config)# clear crypto sa entry <i>destination-address protocol spi</i>	Clears existing IPsec security associations so that any changes to a transform set will take effect on subsequently established security associations. (Manually established SAs are reestablished immediately.) Using the clear crypto sa command without parameters will clear out the full SA database, which will clear out active security sessions. You may also specify the peer , map , or entry keywords to clear out only a subset of the SA database. For more information, see the clear crypto sa command.

[Table 25](#) shows allowed transform combinations.

Table 25 Allowed Transform Combinations

Transform Type	Transform	Description
AH Transform (<i>Pick up to one.</i>)		
	ah-md5-hmac	AH with the MD5 (HMAC variant) authentication algorithm
	ah-sha-hmac	AH with the SHA (HMAC variant) authentication algorithm
	ah-sha-hmac	AH with the SHA (HMAC variant) authentication algorithm

Table 25 Allowed Transform Combinations (continued)

Transform Type	Transform	Description
ESP Encryption Transform (<i>Pick up to one.</i>)		
	esp-des	ESP with the 56-bit DES encryption algorithm
	esp-3des	ESP with the 168-bit DES encryption algorithm (3DES or Triple DES)
	esp-null	Null encryption algorithm
ESP Authentication Transform (<i>Pick up to one.</i>)		
	esp-md5-hmac	ESP with the MD5 (HMAC variant) authentication algorithm
	esp-sha-hmac	ESP with the SHA (HMAC variant) authentication algorithm
IP Compression Transform (<i>Pick up to one.</i>)		
	comp-lzs	IP compression with the LZS algorithm.

Creating Crypto Map Entries

To create crypto map entries, follow the guidelines and tasks described in these sections:

- [About Crypto Maps](#)
- [Load Sharing](#)
- [How Many Crypto Maps Should You Create?](#)
- [Creating Crypto Map Entries to Establish Manual Security Associations](#)
- [Creating Crypto Map Entries that Use IKE to Establish Security Associations](#)
- [Creating Dynamic Crypto Maps](#)

About Crypto Maps

Crypto map entries created for IPsec pull together the various parts used to set up IPsec security associations, including:

- Which traffic should be protected by IPsec (per a crypto access list)
- The granularity of the flow to be protected by a set of security associations
- Where IPsec-protected traffic should be sent (who the remote IPsec peer is)
- The local address to be used for the IPsec traffic (See the [“Applying Crypto Map Sets to Interfaces”](#) section for more details.)
- What IPsec security should be applied to this traffic (selecting from a list of one or more transform sets)

- Whether security associations are manually established or are established via IKE
- Other parameters that might be necessary to define an IPSec security association

Crypto map entries with the same crypto map name (but different map sequence numbers) are grouped into a crypto map set. Later, you will apply these crypto map sets to interfaces; then, all IP traffic passing through the interface is evaluated against the applied crypto map set. If a crypto map entry sees outbound IP traffic that should be protected and the crypto map specifies the use of IKE, a security association is negotiated with the remote peer according to the parameters included in the crypto map entry; otherwise, if the crypto map entry specifies the use of manual security associations, a security association should have already been established via configuration. (If a dynamic crypto map entry sees outbound traffic that should be protected and no security association exists, the packet is dropped.)

The policy described in the crypto map entries is used during the negotiation of security associations. If the local router initiates the negotiation, it will use the policy specified in the static crypto map entries to create the offer to be sent to the specified IPSec peer. If the IPSec peer initiates the negotiation, the local router will check the policy from the static crypto map entries, as well as any referenced dynamic crypto map entries to decide whether to accept or reject the peer's request (offer).

For IPSec to succeed between two IPSec peers, both peers' crypto map entries must contain compatible configuration statements.

When two peers try to establish a security association, they must each have at least one crypto map entry that is compatible with one of the other peer's crypto map entries. For two crypto map entries to be compatible, they must at least meet the following criteria:

- The crypto map entries must contain compatible crypto access lists (for example, mirror image access lists). In the case where the responding peer is using dynamic crypto maps, the entries in the local crypto access list must be "permitted" by the peer's crypto access list.
- The crypto map entries must each identify the other peer (unless the responding peer is using dynamic crypto maps).
- The crypto map entries must have at least one transform set in common.

Load Sharing

You can define multiple remote peers using crypto maps to allow for load sharing. If one peer fails, there will still be a protected path. The peer that packets are actually sent to is determined by the last peer that the router heard from (received either traffic or a negotiation request from) for a given data flow. If the attempt fails with the first peer, IKE tries the next peer on the crypto map list.

If you are not sure how to configure each crypto map parameter to guarantee compatibility with other peers, you might consider configuring dynamic crypto maps as described in the "[Creating Dynamic Crypto Maps](#)" section. Dynamic crypto maps are useful when the establishment of the IPSec tunnels is initiated by the remote peer (such as in the case of an IPSec router fronting a server). They are not useful if the establishment of the IPSec tunnels is locally initiated, because the dynamic crypto maps are policy templates, not complete statements of policy. (Although the access lists in any referenced dynamic crypto map entry are used for crypto packet filtering.)

How Many Crypto Maps Should You Create?

You can apply only one crypto map set to a single interface. The crypto map set can include a combination of IPSec/IKE and IPSec/manual entries. Multiple interfaces can share the same crypto map set if you want to apply the same policy to multiple interfaces.

If you create more than one crypto map entry for a given interface, use the *seq-num* of each map entry to rank the map entries: the lower the *seq-num*, the higher the priority. At the interface that has the crypto map set, traffic is evaluated against higher priority map entries first.

You must create multiple crypto map entries for a given interface if any of the following conditions exist:

- If different data flows are to be handled by separate IPsec peers.
- If you want to apply different IPsec security to different types of traffic (to the same or separate IPsec peers); for example, if you want traffic between one set of subnets to be authenticated, and traffic between another set of subnets to be both authenticated and encrypted. In this case the different types of traffic should have been defined in two separate access lists, and you must create a separate crypto map entry for each crypto access list.
- If you are not using IKE to establish a particular set of security associations, and want to specify multiple access list entries, you must create separate access lists (one per **permit** entry) and specify a separate crypto map entry for each access list.

Creating Crypto Map Entries to Establish Manual Security Associations

The use of manual security associations is a result of a prior arrangement between the users of the local router and the IPsec peer. The two parties may wish to begin with manual security associations, and then move to using security associations established via IKE, or the remote party's system may not support IKE. If IKE is not used for establishing the security associations, there is no negotiation of security associations, so the configuration information in both systems must be the same in order for traffic to be processed successfully by IPsec.

The local router can simultaneously support manual and IKE-established security associations, even within a single crypto map set. There is very little reason to disable IKE on the local router (unless the router only supports manual security associations, which is unlikely).

To create crypto map entries to establish manual security associations (SAs) (that is, when IKE is not used to establish the SAs), use the following commands starting in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto map <i>map-name seq-num ipsec-manual</i>	Specifies the crypto map entry to create (or modify). This command puts you into the crypto map configuration mode.
Step 2	Router(config-crypto-m)# match address <i>access-list-id</i>	Names an IPsec access list. This access list determines which traffic should be protected by IPsec and which traffic should not be protected by IPsec security in the context of this crypto map entry. (The access list can specify only one permit entry when IKE is not used.)
Step 3	Router(config-crypto-m)# set peer { <i>hostname</i> <i>ip-address</i> }	Specifies the remote IPsec peer. This is the peer to which IPsec protected traffic should be forwarded. (Only one peer can be specified when IKE is not used.)

	Command	Purpose
Step 4	Router(config-crypto-m)# set transform-set <i>transform-set-name</i>	Specifies which transform set should be used. This must be the same transform set that is specified in the remote peer's corresponding crypto map entry. (Only one transform set can be specified when IKE is not used.)
Step 5	Router(config-crypto-m)# set session-key inbound ah <i>spi hex-key-string</i> and Router(config-crypto-m)# set session-key outbound ah <i>spi hex-key-string</i>	Sets the AH Security Parameter Indexes (SPIs) and keys to apply to inbound and outbound protected traffic if the specified transform set includes the AH protocol. (This manually specifies the AH security association to be used with protected traffic.)
Step 6	Router(config-crypto-m)# set session-key inbound esp <i>spi cipher hex-key-string [authenticator hex-key-string]</i> and Router(config-crypto-m)# set session-key outbound esp <i>spi cipher hex-key-string [authenticator hex-key-string]</i>	Sets the ESP Security Parameter Indexes (SPIs) and keys to apply to inbound and outbound protected traffic if the specified transform set includes the ESP protocol. Specifies the cipher keys if the transform set includes an ESP cipher algorithm. Specifies the authenticator keys if the transform set includes an ESP authenticator algorithm. (This manually specifies the ESP security association to be used with protected traffic.)
Step 7	Router(config-crypto-m)# exit	Exits crypto-map configuration mode and return to global configuration mode.

Repeat these steps to create additional crypto map entries as required.

Creating Crypto Map Entries that Use IKE to Establish Security Associations

When IKE is used to establish security associations, the IPSec peers can negotiate the settings they will use for the new security associations. This means that you can specify lists (such as lists of acceptable transforms) within the crypto map entry.

To create crypto map entries that will use IKE to establish the security associations, use the following commands starting in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto map <i>map-name seq-num ipsec-isakmp</i>	Names the crypto map entry to create (or modify). This command puts you into the crypto map configuration mode.
Step 2	Router(config-crypto-m)# match address <i>access-list-id</i>	Names an extended access list. This access list determines which traffic should be protected by IPSec and which traffic should not be protected by IPSec security in the context of this crypto map entry.
Step 3	Router(config-crypto-m)# set peer { <i>hostname</i> <i>ip-address</i> }	Specifies a remote IPSec peer. This is the peer to which IPSec protected traffic can be forwarded. Repeat for multiple remote peers.

	Command	Purpose
Step 4	Router(config-crypto-m)# set transform-set <i>transform-set-name1</i> [<i>transform-set-name2</i> ... <i>transform-set-name6</i>]	Specifies which transform sets are allowed for this crypto map entry. List multiple transform sets in order of priority (highest priority first).
Step 5	Router(config-crypto-m)# set security-association lifetime seconds <i>seconds</i> and Router (config-crypto-m)# set security-association lifetime kilobytes <i>kilobytes</i>	(Optional) Specifies a security association lifetime for the crypto map entry. Use this command if you want the security associations for this crypto map entry to be negotiated using different IPSec security association lifetimes than the global lifetimes.
Step 6	Router(config-crypto-m)# set security-association level per-host	(Optional) Specifies that separate security associations should be established for each source/destination host pair. Without this command, a single IPSec “tunnel” could carry traffic for multiple source hosts and multiple destination hosts. With this command, when the router requests new security associations it will establish one set for traffic between Host A and Host B, and a separate set for traffic between Host A and Host C. Use this command with care, as multiple streams between given subnets can rapidly consume resources.
Step 7	Router(config-crypto-m)# set pfs [group1 group2]	(Optional) Specifies that IPSec should ask for perfect forward secrecy when requesting new security associations for this crypto map entry, or should demand PFS in requests received from the IPSec peer.
Step 8	Router(config-crypto-m)# exit	Exits crypto-map configuration mode and return to global configuration mode.

Repeat these steps to create additional crypto map entries as required.

Creating Dynamic Crypto Maps

Dynamic crypto maps (this requires IKE) can ease IPSec configuration and are recommended for use with networks where the peers are not always predetermined. An example of this is mobile users, who obtain dynamically-assigned IP addresses. First, the mobile clients need to authenticate themselves to the local router’s IKE by something other than an IP address, such as a fully qualified domain name. Once authenticated, the security association request can be processed against a dynamic crypto map which is set up to accept requests (matching the specified local policy) from previously unknown peers.

To configure dynamic crypto maps, follow the instructions in these sections:

- [Understanding Dynamic Crypto Maps](#)
- [Creating a Dynamic Crypto Map Set](#)
- [Adding the Dynamic Crypto Map Set into a Regular \(Static\) Crypto Map Set](#)

Understanding Dynamic Crypto Maps

Dynamic crypto maps are only available for use by IKE.

A dynamic crypto map entry is essentially a crypto map entry without all the parameters configured. It acts as a policy template where the missing parameters are later dynamically configured (as the result of an IPSec negotiation) to match a remote peer's requirements. This allows remote peers to exchange IPSec traffic with the router even if the router does not have a crypto map entry specifically configured to meet all of the remote peer's requirements.

Dynamic crypto maps are not used by the router to initiate new IPSec security associations with remote peers. Dynamic crypto maps are used when a remote peer tries to initiate an IPSec security association with the router. Dynamic crypto maps are also used in evaluating traffic.

A dynamic crypto map set is included by reference as part of a crypto map set. Any crypto map entries that reference dynamic crypto map sets should be the lowest priority crypto map entries in the crypto map set (that is, have the highest sequence numbers) so that the other crypto map entries are evaluated first; that way, the dynamic crypto map set is examined only when the other (static) map entries are not successfully matched.

If the router accepts the peer's request, at the point that it installs the new IPSec security associations it also installs a temporary crypto map entry. This entry is filled in with the results of the negotiation. At this point, the router performs normal processing, using this temporary crypto map entry as a normal entry, even requesting new security associations if the current ones are expiring (based upon the policy specified in the temporary crypto map entry). Once the flow expires (that is, all of the corresponding security associations expire), the temporary crypto map entry is then removed.

For both static and dynamic crypto maps, if unprotected inbound traffic matches a **permit** statement in an access list, and the corresponding crypto map entry is tagged as "IPSec," then the traffic is dropped because it is not IPSec-protected. (This is because the security policy as specified by the crypto map entry states that this traffic must be IPSec-protected.)

For static crypto map entries, if outbound traffic matches a **permit** statement in an access list and the corresponding SA is not yet established, the router will initiate new SAs with the remote peer. In the case of dynamic crypto map entries, if no SA existed, the traffic would simply be dropped (because dynamic crypto maps are not used for initiating new SAs).



Note

Use care when using the **any** keyword in **permit** entries in dynamic crypto maps. If it is possible for the traffic covered by such a **permit** entry to include multicast or broadcast traffic, the access list should include **deny** entries for the appropriate address range. Access lists should also include **deny** entries for network and subnet broadcast traffic, and for any other traffic that should not be IPSec protected.

Creating a Dynamic Crypto Map Set

Dynamic crypto map entries, like regular static crypto map entries, are grouped into sets. A set is a group of dynamic crypto map entries all with the same *dynamic-map-name* but each with a different *dynamic-seq-num*.

To create a dynamic crypto map entry, use the following commands starting in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto dynamic-map <i>dynamic-map-name</i> <i>dynamic-seq-num</i>	Creates a dynamic crypto map entry.
Step 2	Router(config-crypto-m)# set transform-set <i>transform-set-name1</i> [<i>transform-set-name2</i> ... <i>transform-set-name6</i>]	Specifies which transform sets are allowed for the crypto map entry. List multiple transform sets in order of priority (highest priority first). This is the only configuration statement required in dynamic crypto map entries.
Step 3	Router(config-crypto-m)# match address <i>access-list-id</i>	(Optional) Accesses list number or name of an extended access list. This access list determines which traffic should be protected by IPSec and which traffic should not be protected by IPSec security in the context of this crypto map entry. Note Although access-lists are optional for dynamic crypto maps, they are highly recommended If this is configured, the data flow identity proposed by the IPSec peer must fall within a permit statement for this crypto access list. If this is not configured, the router will accept any data flow identity proposed by the IPSec peer. However, if this is configured but the specified access list does not exist or is empty, the router will drop all packets. This is similar to static crypto maps because they also require that an access list be specified. Care must be taken if the any keyword is used in the access list, because the access list is used for packet filtering as well as for negotiation.
Step 4	Router(config-crypto-m)# set peer { <i>hostname</i> <i>ip-address</i> }	(Optional) Specifies a remote IPSec peer. Repeat for multiple remote peers. This is rarely configured in dynamic crypto map entries. Dynamic crypto map entries are often used for unknown remote peers.
Step 5	Router(config-crypto-m)# set security-association lifetime seconds <i>seconds</i> and Router (config-crypto-m)# set security-association lifetime kilobytes <i>kilobytes</i>	(Optional) If you want the security associations for this crypto map to be negotiated using shorter IPSec security association lifetimes than the globally specified lifetimes, specify a key lifetime for the crypto map entry.

	Command	Purpose
Step 6	Router(config-crypto-m)# set pfs [group1 group2]	(Optional) Specifies that IPsec should ask for perfect forward secrecy when requesting new security associations for this crypto map entry or should demand perfect forward secrecy in requests received from the IPsec peer.
Step 7	Router(config-crypto-m)# exit	Exits crypto-map configuration mode and return to global configuration mode.

Dynamic crypto map entries specify crypto access lists that limit traffic for which IPsec security associations can be established. A dynamic crypto map entry that does not specify an access list will be ignored during traffic filtering. A dynamic crypto map entry with an empty access list causes traffic to be dropped. If there is only one dynamic crypto map entry in the crypto map set, it must specify acceptable transform sets.

Adding the Dynamic Crypto Map Set into a Regular (Static) Crypto Map Set

You can add one or more dynamic crypto map sets into a crypto map set, via crypto map entries that reference the dynamic crypto map sets. You should set the crypto map entries referencing dynamic maps to be the lowest priority entries in a crypto map set (that is, have the highest sequence numbers).

To add a dynamic crypto map set into a crypto map set, use the following command in global configuration mode:

Command	Purpose
Router(config)# crypto map map-name seq-num ipsec-isakmp dynamic dynamic-map-name	Adds a dynamic crypto map set to a static crypto map set.

Applying Crypto Map Sets to Interfaces

You need to apply a crypto map set to each interface through which IPsec traffic will flow. Applying the crypto map set to an interface instructs the router to evaluate all the interface's traffic against the crypto map set and to use the specified policy during connection or security association negotiation on behalf of traffic to be protected by crypto.

To apply a crypto map set to an interface, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# crypto map map-name	Applies a crypto map set to an interface.

For redundancy, you could apply the same crypto map set to more than one interface. The default behavior is as follows:

- Each interface will have its own piece of the security association database.
- The IP address of the local interface will be used as the local address for IPsec traffic originating from or destined to that interface.

If you apply the same crypto map set to multiple interfaces for redundancy purposes, you need to specify an identifying interface. This has the following effects:

- The per-interface portion of the IPSec security association database will be established one time and shared for traffic through all the interfaces that share the same crypto map.
- The IP address of the identifying interface will be used as the local address for IPSec traffic originating from or destined to those interfaces sharing the same crypto map set.

One suggestion is to use a loopback interface as the identifying interface.

To specify redundant interfaces and name an identifying interface, use the following command in global configuration mode:

Command	Purpose
Router(config)# crypto map <i>map-name</i> local-address <i>interface-id</i>	Permits redundant interfaces to share the same crypto map, using the same local identity.

Monitoring and Maintaining IPSec

Certain configuration changes will only take effect when negotiating subsequent security associations. If you want the new settings to take immediate effect, you must clear the existing security associations so that they will be re-established with the changed configuration. For manually established security associations, you must clear and reinitialize the security associations or the changes will never take effect. If the router is actively processing IPSec traffic, it is desirable to clear only the portion of the security association database that would be affected by the configuration changes (that is, clear only the security associations established by a given crypto map set). Clearing the full security association database should be reserved for large-scale changes, or when the router is processing very little other IPSec traffic.

To clear (and reinitialize) IPSec security associations, use one of the following commands in global configuration mode:

Command	Purpose
Router(config)# clear crypto sa	<p>Clears IPSec security associations.</p> <p>Note Using the clear crypto sa command without parameters will clear out the full SA database, which will clear out active security sessions. You may also specify the peer, map, or entry keywords to clear out only a subset of the SA database. For more information, see the clear crypto sa command.</p>
or	
Router(config)# clear crypto sa peer { <i>ip-address</i> <i>peer-name</i> }	
or	
Router(config)# clear crypto sa map <i>map-name</i>	
or	
Router(config)# clear crypto sa entry <i>destination-address protocol spi</i>	

To view information about your IPsec configuration, use one or more of the following commands in EXEC mode:

Command	Purpose
Router# show crypto ipsec transform-set	Displays your transform set configuration.
Router# show crypto map [interface <i>interface</i> tag <i>map-name</i>]	Displays your crypto map configuration.
Router# show crypto ipsec sa [map <i>map-name</i> address identity] [detail]	Displays information about IPsec security associations.
Router# show crypto dynamic-map [tag <i>map-name</i>]	Displays information about dynamic crypto maps.
Router# show crypto ipsec security-association lifetime	Displays global security association lifetime values.

IPsec Configuration Example

The following example shows a minimal IPsec configuration where the security associations will be established via IKE. For more information about IKE, see the “Configuring Internet Key Exchange Security Protocol” chapter.

An IPsec access list defines which traffic to protect:

```
access-list 101 permit ip 10.0.0.0 0.0.0.255 10.2.2.0 0.0.0.255
```

A transform set defines how the traffic will be protected. In this example, transform set “myset1” uses DES encryption and SHA for data packet authentication:

```
crypto ipsec transform-set myset1 esp-des esp-sha
```

Another transform set example is “myset2,” which uses Triple DES encryptions and MD5 (HMAC variant) for data packet authentication:

```
crypto ipsec transform-set myset2 esp-3des esp-md5-hmac
```

A crypto map joins together the IPsec access list and transform set and specifies where the protected traffic is sent (the remote IPsec peer):

```
crypto map toRemoteSite 10 ipsec-isakmp
 match address 101
 set transform-set myset2
 set peer 10.2.2.5
```

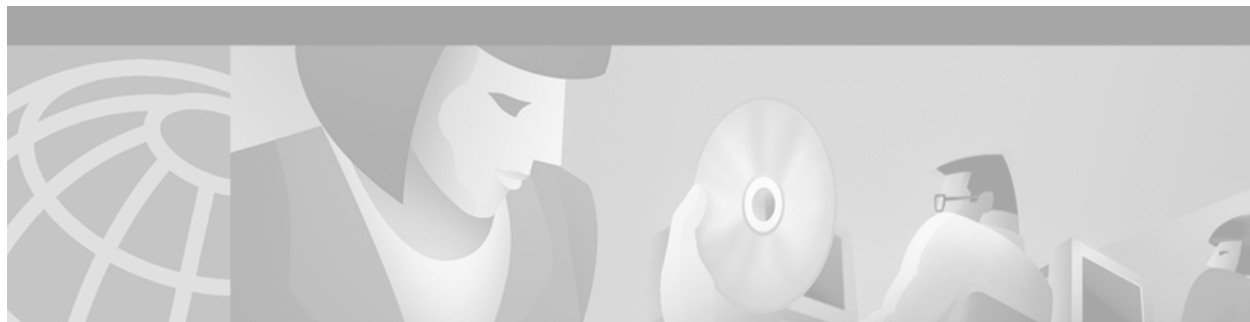
The crypto map is applied to an interface:

```
interface Serial0
 ip address 10.0.0.2
 crypto map toRemoteSite
```



Note

In this example, IKE must be enabled.



Configuring Certification Authority Interoperability

This chapter describes how to configure certification authority (CA) interoperability, which is provided in support of the IP Security (IPSec) protocol. CA interoperability permits Cisco IOS devices and CAs to communicate so that your Cisco IOS device can obtain and use digital certificates from the CA. Although IPSec can be implemented in your network without the use of a CA, using a CA provides manageability and scalability for IPSec.

For background and configuration information for IPSec, see the chapter “Configuring IPSec Network Security.”

For a complete description of the commands used in this chapter, refer to the chapter “Certification Authority Interoperability Commands” in the *Cisco IOS Security Command Reference*. To locate documentation for other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the “Identifying Supported Platforms” section in the chapter “Using Cisco IOS Software.”

In This Chapter

This chapter contains the following sections:

- [About CA Interoperability](#)
- [About Certification Authorities](#)
- [CA Interoperability Configuration Task Lists](#)
- [What to Do Next](#)
- [CA Interoperability Configuration Examples](#)

About CA Interoperability

Without CA interoperability, Cisco IOS devices could not use CAs when deploying IPSec. CAs provide a manageable, scalable solution for IPSec networks. For details, see the section “[About Certification Authorities](#).”

This section contains the following sections:

- [Supported Standards](#)
- [Restrictions](#)
- [Prerequisites](#)

Supported Standards

Cisco supports the following standards with this feature:

- **IPSec**—IP Security Protocol. IPSec is a framework of open standards that provides data confidentiality, data integrity, and data authentication between participating peers. IPSec provides these security services at the IP layer; it uses Internet Key Exchange to handle negotiation of protocols and algorithms based on local policy, and to generate the encryption and authentication keys to be used by IPSec. IPSec can be used to protect one or more data flows between a pair of hosts, between a pair of security gateways, or between a security gateway and a host.

For more information on IPSec, see the chapter “Configuring IPSec Network Security.”

- **Internet Key Exchange (IKE)**—A hybrid protocol that implements Oakley and Skeme key exchanges inside the Internet Security Association Key Management Protocol (ISAKMP) framework. Although IKE can be used with other protocols, its initial implementation is with the IPSec protocol. IKE provides authentication of the IPSec peers, negotiates IPSec keys, and negotiates IPSec security associations.

For more information on IKE, see the chapter “Configuring Internet Key Exchange Security Protocol.”

- **Public-Key Cryptography Standard #7 (PKCS #7)**—A standard from RSA Data Security, Inc., used to encrypt and sign certificate enrollment messages.
- **Public-Key Cryptography Standard #10 (PKCS #10)**—A standard syntax from RSA Data Security, Inc. for certificate requests.
- **RSA Keys**—RSA is the public key cryptographic system developed by Ron Rivest, Adi Shamir, and Leonard Adleman. RSA keys come in pairs: one public key and one private key.
- **X.509v3 certificates**—Certificate support that allows the IPSec-protected network to scale by providing the equivalent of a digital ID card to each device. When two devices wish to communicate, they exchange digital certificates to prove their identity (thus removing the need to manually exchange public keys with each peer or to manually specify a shared key at each peer). These certificates are obtained from a certification authority (CA). X.509 is part of the X.500 standard of the ITU.

Restrictions

When configuring your CA, the following restrictions apply:

- This feature should be configured only when you also configure both IPsec and IKE in your network.
- The Cisco IOS software *does not* support CA server public keys greater than 2048 bits.

Prerequisites

You need to have a certification authority (CA) available to your network before you configure this interoperability feature. The CA must support Cisco Systems' PKI protocol, the Simple Certificate Enrollment Protocol (SCEP) (formerly called certificate enrollment protocol (CEP)).

About Certification Authorities

This section provides background information about CAs, including the following:

- [Purpose of CAs](#)
- [Implementing IPsec Without CAs](#)
- [Implementing IPsec with CAs](#)
- [Implementing IPsec with Multiple Root CAs](#)
- [How CA Certificates Are Used by IPsec Devices](#)
- [About Registration Authorities](#)

Purpose of CAs

CAs are responsible for managing certificate requests and issuing certificates to participating IPsec network devices. These services provide centralized key management for the participating devices.

CAs simplify the administration of IPsec network devices. You can use a CA with a network containing multiple IPsec-compliant devices such as routers.

Digital signatures, enabled by public key cryptography, provide a means of digitally authenticating devices and individual users. In public key cryptography, such as the RSA encryption system, each user has a key pair containing both a public and a private key. The keys act as complements, and anything encrypted with one of the keys can be decrypted with the other. In simple terms, a signature is formed when data is encrypted with a user's private key. The receiver verifies the signature by decrypting the message with the sender's public key. The fact that the message could be decrypted using the sender's public key indicates that the holder of the private key, the sender, must have created the message. This process relies on the receiver's having a copy of the sender's public key and knowing with a high degree of certainty that it really does belong to the sender and not to someone pretending to be the sender.

Digital certificates provide the link. A digital certificate contains information to identify a user or device, such as the name, serial number, company, department, or IP address. It also contains a copy of the entity's public key. The certificate is itself signed by a certification authority (CA), a third party that is explicitly trusted by the receiver to validate identities and to create digital certificates.

In order to validate the signature of the CA, the receiver must first know the CA's public key. Normally this process is handled out-of-band or through an operation done at installation. For instance, most web browsers are configured with the public keys of several CAs by default. The Internet Key Exchange (IKE), an essential component of IPSec, can use digital signatures to scalably authenticate peer devices before setting up security associations.

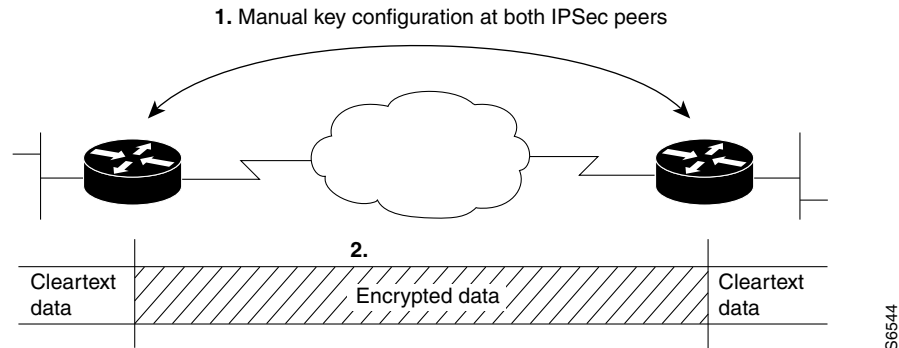
Without digital signatures, one must manually exchange either public keys or secrets between each pair of devices that use IPSec to protect communications between them. Without certificates, every new device added to the network requires a configuration change on every other device with which it communicates securely. With digital certificates, each device is enrolled with a certification authority. When two devices wish to communicate, they exchange certificates and digitally sign data to authenticate each other. When a new device is added to the network, one simply enrolls that device with a CA, and none of the other devices needs modification. When the new device attempts an IPSec connection, certificates are automatically exchanged and the device can be authenticated.

Implementing IPSec Without CAs

Without a CA, if you want to enable IPSec services (such as encryption) between two Cisco routers, you must first ensure that each router has the key of the other router (such as an RSA public key or a shared key). This requirement means that you must manually perform one of the following operations:

- At each router, enter the RSA public key of the other router
- At each router, specify a shared key to be used by both routers

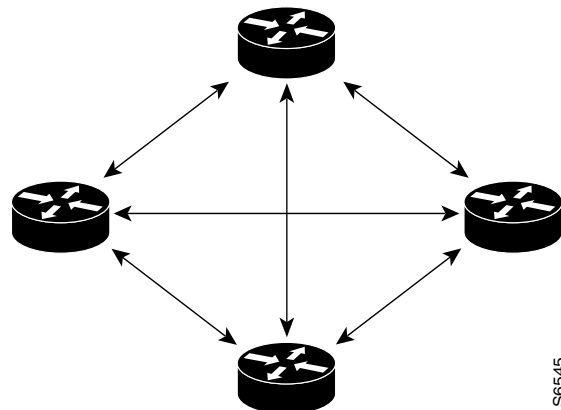
Figure 33 Without a CA: Key Configuration Between Two Routers



In [Figure 33](#), each router uses the key of the other router to authenticate the identity of the other router; this authentication always occurs when IPSec traffic is exchanged between the two routers.

If you have multiple Cisco routers in a mesh topology and wish to exchange IPSec traffic passing among all of those routers, you must first configure shared keys or RSA public keys among all of those routers.

Figure 34 Without a CA: Six Two-Part Key Configurations Required for Four IPSec Routers



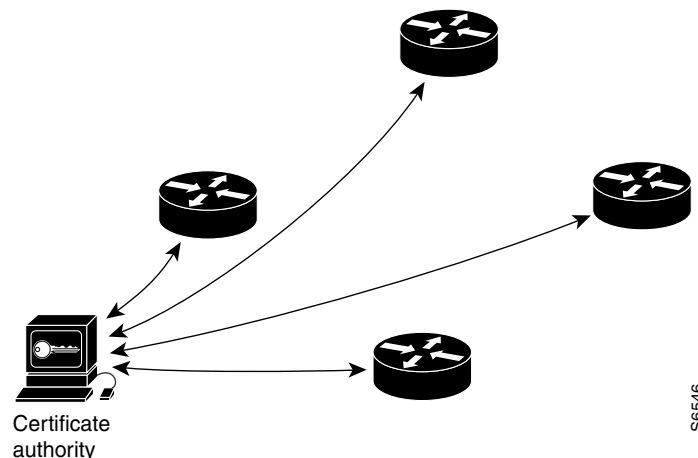
Every time a new router is added to the IPSec network, you must configure keys between the new router and each of the existing routers. (In [Figure 34](#), four additional two-part key configurations would be required to add a single encrypting router to the network.)

Consequently, the more devices there are that require IPSec services, the more involved the key administration becomes. This approach does not scale well for larger, more complex encrypting networks.

Implementing IPSec with CAs

With a CA, you do not have to configure keys between all the encrypting routers. Instead, you individually enroll each participating router with the CA, requesting a certificate for the router. When this has been accomplished, each participating router can dynamically authenticate all the other participating routers. This process is illustrated in [Figure 35](#).

Figure 35 With a CA: Each Router Individually Makes Requests of the CA at Installation



To add a new IPSec router to the network, you need only configure that new router to request a certificate from the CA, instead of making multiple key configurations with all the other existing IPSec routers.

Implementing IPsec with Multiple Root CAs

With multiple root CAs, you no longer have to enroll a router with the CA that issued a certificate to a peer. Instead, you configure a router with multiple CAs that it trusts. Thus, a router can use a configured CA (a trusted root) to verify certificates offered by a peer that were not issued by the same CA defined in the identity of the router.

Configuring multiple CAs allows two or more routers enrolled under different domains (different CAs) to verify the identity of each other when using IKE to set up IPsec tunnels.

Through Simple Certificate Enrollment Protocol (SCEP), each router is configured with a CA (the enrollment CA). The CA issues a certificate to the router that is signed with the private key of the CA. To verify the certificates of peers in the same domain, the router is also configured with the root certificate of the enrollment CA.

To verify the certificate of a peer from a different domain, the root certificate of the enrollment CA in the domain of the peer must be configured securely in the router.

During IKE phase one signature verification, the initiator will send the responder a list of its CA certificates. The responder should send the certificate issued by one of the CAs in the list. If the certificate is verified, the router saves the public key contained in the certificate on its public key ring.

With multiple root CAs, Virtual Private Network (VPN) users can establish trust in one domain and easily and securely distribute it to other domains. Thus, the required private communication channel between entities authenticated under different domains can occur.

How CA Certificates Are Used by IPsec Devices

When two IPsec routers want to exchange IPsec-protected traffic passing between them, they must first authenticate each other—otherwise, IPsec protection cannot occur. The authentication is done with IKE.

Without a CA, a router authenticates itself to the remote router using either RSA-encrypted nonces or preshared keys. Both methods require that keys must have been previously configured between the two routers.

With a CA, a router authenticates itself to the remote router by sending a certificate to the remote router and performing some public key cryptography. Each router must send its own unique certificate that was issued and validated by the CA. This process works because the certificate of each router encapsulates the public key of the router, each certificate is authenticated by the CA, and all participating routers recognize the CA as an authenticating authority. This scheme is called IKE with an RSA signature.

Your router can continue sending its own certificate for multiple IPsec sessions, and to multiple IPsec peers until the certificate expires. When its certificate expires, the router administrator must obtain a new one from the CA.

CAs can also revoke certificates for devices that will no longer participate in IPsec. Revoked certificates are not recognized as valid by other IPsec devices. Revoked certificates are listed in a certificate revocation list (CRL), which each peer may check before accepting a certificate from another peer.

About Registration Authorities

Some CAs have a registration authority (RA) as part of their implementation. An RA is essentially a server that acts as a proxy for the CA so that CA functions can continue when the CA is offline.

Some of the configuration tasks described in this document differ slightly, depending on whether your CA supports an RA.

CA Interoperability Configuration Task Lists

To enable your Cisco device to interoperate with a CA, complete the tasks in the following sections. Some of the tasks are optional; the remaining are required.

- [Managing NVRAM Memory Usage](#) (Optional)
- [Configuring the Routers Host Name and IP Domain Name](#) (Required)
- [Generating an RSA Key Pair](#) (Required)
- [Declaring a Certification Authority](#) (Required)
- [Configuring a Root CA \(Trusted Root\)](#) (Optional)
- [Authenticating the CA](#) (Required)
- [Requesting Your Own Certificates](#) (Required)
- [Saving Your Configuration](#) (Required)
- [Monitoring and Maintaining Certification Authority Interoperability](#) (Optional)

For CA interoperability configuration examples, refer to the section “[CA Interoperability Configuration Examples](#)” at the end of this chapter.

Managing NVRAM Memory Usage

Certificates and certificate revocation lists (CRLs) are used by your router when a CA is used. Normally certain certificates and all CRLs are stored locally in the router’s NVRAM, and each certificate and CRL uses a moderate amount of memory.

The following certificates are normally stored at your router:

- The certificate of your router
- The certificate of the CA
- Root certificates obtained from CA servers (all root certificates are saved in RAM after the router has been initialized)
- Two registration authority (RA) certificates (only if the CA supports an RA)

CRLs are normally stored at your router according to the following conditions:

- If your CA does not support an RA, only one CRL gets stored at your router.
- If your CA supports an RA, multiple CRLs can be stored at your router.

In some cases, storing these certificates and CRLs locally will not present any difficulty. In other cases, memory might become a problem—particularly if your CA supports an RA and a large number of CRLs have to be stored on your router. If the NVRAM is too small to store root certificates, only the fingerprint of the root certificate will be saved.

To save NVRAM space, you can specify that certificates and CRLs should not be stored locally, but should be retrieved from the CA when needed. This alternative will save NVRAM space but could result in a slight performance impact.

To specify that certificates and CRLs should not be stored locally on your router, but should be retrieved when required, turn on query mode by using the following command in global configuration mode:

Command	Purpose
Router(config)# crypto ca certificate query	Turns on query mode, which causes certificates and CRLs not to be stored locally.

**Note**

Query mode may affect availability if the CA is down.

If you do not turn on query mode now, you can turn it on later even if certificates and CRLs have already been stored on your router. In this case, when you turn on query mode, the stored certificates and CRLs will be deleted from the router after you save your configuration. (If you copy your configuration to a TFTP site prior to turning on query mode, you will save any stored certificates and CRLs at the TFTP site.)

If you turn on query mode now, you can turn off query mode later if you wish. If you turn off query mode later, you could also perform the **copy system:running-config nvram:startup-config** command at that time to save all current certificates and CRLs to NVRAM. Otherwise they could be lost during a reboot and would need to be retrieved the next time they were needed by your router.

Configuring the Routers Host Name and IP Domain Name

You must configure the host name and IP domain name of the router if this has not already been done. This is required because the router assigns a fully qualified domain name (FQDN) to the keys and certificates used by IPsec, and the FQDN is based on the host name and IP domain name you assign to the router. For example, a certificate named “router20.example.com” is based on a router host name of “router20” and a router IP domain name of “example.com”.

To configure the host name and IP domain name of the router, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# hostname <i>name</i>	Configures the host name of the router.
Step 2	Router(config)# ip domain-name <i>name</i>	Configures the IP domain name of the router.

Generating an RSA Key Pair

RSA key pairs are used to sign and encrypt IKE key management messages and are required before you can obtain a certificate for your router.

To generate an RSA key pair, use the following command in global configuration mode:

Command	Purpose
Router(config)# crypto key generate rsa [usage-keys]	Generates an RSA key pair. Use the usage-keys keyword to specify special-usage keys instead of general-purpose keys. See the <i>Cisco IOS Security Command Reference</i> for an explanation of special-usage versus general-purpose keys for this command.

Declaring a Certification Authority

You should declare one certification authority (CA) to be used by your router.

To declare a CA, use the following commands, beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto ca identity <i>name</i>	Declares a CA. The name should be the domain name of the CA. This command puts you into the ca-identity configuration mode.
Step 2	Router(ca-identity)# enrollment url <i>url</i>	Specifies the URL of the CA. (The URL should include any nonstandard cgi-bin script location.)
Step 3	Router(ca-identity)# enrollment mode <i>ra</i>	(Optional) Specifies RA mode if your CA system provides a registration authority (RA). Note The Cisco IOS software automatically determines the mode—RA or non-RA; therefore, if RA mode is used, this subcommand is written to NVRAM during “write memory.”
Step 4	Router(ca-identity)# query url <i>url</i>	Specifies the location of the LDAP server if your CA system provides an RA and supports the LDAP protocol.
Step 5	Router(ca-identity)# enrollment retry period <i>minutes</i>	(Optional) Specifies a retry period. After requesting a certificate, the router waits to receive a certificate from the CA. If the router does not receive a certificate within a period of time (the retry period) the router will send another certificate request. You can change the retry period from the default of 1 minute.
Step 6	Router(ca-identity)# enrollment retry count <i>number</i>	(Optional) Specifies how many times the router will continue to send unsuccessful certificate requests before giving up. By default, the router will never give up trying.

	Command	Purpose
Step 7	Router(ca-identity)# crl optional	(Optional) Specifies that other peers' certificates can still be accepted by your router even if the appropriate CRL is not accessible to your router.
Step 8	Router(ca-identity)# exit	Exits ca-identity configuration mode.

The trade-off between security and availability is determined by the **query url** and **crl optional** commands, as shown in [Table 26](#).



Table 26 Security and CA Availability

	Query—Yes	Query—No
CRL Optional—Yes	Sessions will go through even if the CA is not available, but the certificate may have been revoked.	Sessions will go through even if the CA is not available, but the certificate may have been revoked.
CRL Optional—No	Certificates will not be accepted if the CA is not available.	Sessions will go through, and will be verified against the CRL stored locally.

Configuring a Root CA (Trusted Root)

To configure a trusted root, enter the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto ca trusted-root name	Configures a root with a selected name and enters trusted root configuration mode.
Step 2	Router(ca-root)# crl query url	(Optional) Queries the CRL published by the configured root with the LDAP ¹ URL.
Step 3	Router(ca-root)# exit	(Optional) Exits trusted root configuration mode.
Step 4	Router(config)# crypto ca identity name	(Optional) Enters certificate authority identity configuration mode.
Step 5	Router(ca-identity)# crl optional	(Optional) Allows other peer certificates to be accepted by your router even if the appropriate CRL is not accessible to your router.
Step 6	Router(ca-identity)# exit	(Optional) Exits certificate authority identity configuration mode.
Step 7	Router(config)# crypto ca trusted-root name	(Optional) Enters trusted root configuration mode.

Command	Purpose
Step 8 Router(ca-root)# root CEP <i>url</i> or Router(ca-root)# root TFTP <i>server-hostname filename</i>	Uses SCEP ² , with the given identity and URL, to get a root certificate. or Uses TFTP to get a root certificate.  Note Only use TFTP if your CA server does not support SCEP.  Note When you are using TFTP, the server must be secured so that the downloading of the root certificate is not subject to any attack.
Step 9 Router(ca-root)# root PROXY <i>url</i>	Defines the HTTP proxy server for getting a root certificate.

1. LDAP = Lightweight Directory Access Protocol.

2. SCEP = Simple Certificate Enrollment Protocol (formerly called Cisco Enrollment Protocol (CEP)).

Authenticating the CA

The router must authenticate the CA. It does this by obtaining the self-signed certificate of the CA, which contains the public key of the CA. Because the certificate of the CA is self-signed (the CA signs its own certificate) the public key of the CA should be manually authenticated by contacting the CA administrator to compare the fingerprint of the CA certificate when you perform this step.

To get the public key of the CA, use the following command in global configuration mode:

Command	Purpose
Router(config)# crypto ca authenticate <i>name</i>	Gets the public key of the CA. Use the same <i>name</i> that you used when declaring the CA or when using the crypto ca identity command.

Requesting Your Own Certificates

You must obtain a signed certificate from the CA for each of your router's RSA key pairs. If you generated general-purpose RSA keys, your router has only one RSA key pair and needs only one certificate. If you previously generated special-usage RSA keys, your router has two RSA key pairs and needs two certificates.

To request signed certificates from the CA, use the following command in global configuration mode:

Command	Purpose
Router(config)# crypto ca enroll <i>name</i>	Requests certificates for all of your RSA key pairs. This command causes your router to request as many certificates as there are RSA key pairs, so you need only perform this command once, even if you have special-usage RSA key pairs. Note This command requires you to create a challenge password that is not saved with the configuration. This password is required in the event that your certificate needs to be revoked, so you must remember this password.

**Note**

If your router reboots after you have issued the **crypto ca enroll** command but before you have received the certificates, you must reissue the command and notify the CA administrator.

Saving Your Configuration

Always remember to save your work when you make configuration changes.

Use the **copy system:running-config nvram:startup-config** command to save your configuration. This command includes saving RSA keys to private NVRAM. RSA keys are *not* saved with your configuration when you use a **copy system:running-config rcp:** or **copy system:running-config tftp:** command.

Monitoring and Maintaining Certification Authority Interoperability

The following tasks are optional, depending on your particular requirements:

- [Requesting a Certificate Revocation List](#)
- [Querying a Certificate Revocation List](#)
- [Deleting RSA Keys from Your Router](#)
- [Deleting a Peer's Public Keys](#)
- [Deleting Certificates from the Configuration](#)
- [Viewing Keys and Certificates](#)

Requesting a Certificate Revocation List

You can request a certificate revocation list (CRL) only if your CA does not support a registration authority (RA). The following description and task applies only when the CA does not support an RA.

When your router receives a certificate from a peer, your router will download a CRL from the CA. Your router then checks the CRL to make sure the certificate that the peer sent has not been revoked. (If the certificate appears on the CRL, your router will not accept the certificate and will not authenticate the peer.)

A CRL can be reused with subsequent certificates until the CRL expires if query mode is off. If your router receives a peer's certificate after the applicable CRL has expired, the router will download the new CRL.

If your router has a CRL that has not yet expired, but you suspect that the contents of the CRL are out of date, you can request that the latest CRL be downloaded immediately to replace the old CRL.

To request immediate download of the latest CRL, use the following command in global configuration mode:

Command	Purpose
Router(config)# crypto ca crl request <i>name</i>	Requests an updated CRL. This command replaces the currently stored CRL at your router with the newest version of the CRL.


Querying a Certificate Revocation List

You can query a certificate revocation list (CRL) only when you configure your router with a trusted root. The following description and task apply only when your router has been configured with a trusted root.

When your router receives a certificate from a peer from another domain (with a different CA), the CRL downloaded from the CA of the router will not include certificate information about the peer. Therefore, you should check the CRL published by the configured root with the LDAP URL to ensure that the certificate of the peer has not been revoked.

If you would like CRL of the root certificate to be queried when the router reboots, you must enter the **crl query** command at this point.

To query the CRL published by the configured root with the LDAP URL, enter the following command in trusted root configuration mode:

Command	Purpose
Router(ca-root)# crl query	Queries the CRL published by the configured root with the LDAP URL. The URL used to query the CRL must be an LDAP URL.
	 Note After you enter this command, an entry is created in the router for the root subject name command. The entry is based on information contained in the router.

Deleting RSA Keys from Your Router

Under certain circumstances you may want to delete your router's RSA keys. For example, if you believe the RSA keys were compromised in some way and should no longer be used, you should delete the keys.

To delete all RSA keys from your router, use the following command in global configuration mode:

Command	Purpose
Router(config)# crypto key zeroize rsa	Deletes all of your router's RSA keys.

After you delete a router's RSA keys, you should also complete these two additional tasks:

- Ask the CA administrator to revoke your router's certificates at the CA; you must supply the challenge password you created when you originally obtained the router's certificates with the **crypto ca enroll** command.
- Manually remove the router's certificates from the router configuration, as described in the section [“Deleting Certificates from the Configuration.”](#)

Deleting a Peer's Public Keys

Under certain circumstances you may want to delete other peers' RSA public keys from your router's configuration. For example, if you no longer trust the integrity of a peer's public key, you should delete the key.

To delete a peer's RSA public key, use the following commands, beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto key pubkey-chain rsa	Enters public key configuration mode.
Step 2	Router(config-pubkey-c)# no named-key <i>key-name</i> [encryption signature] or Router(config-pubkey-c)# no addressed-key <i>key-address</i> [encryption signature]	Deletes a remote peer's RSA public key. Specify the peer's fully qualified domain name or the remote peer's IP address.
Step 3	exit	Returns to global configuration mode.

Deleting Certificates from the Configuration

If the need arises, you can delete certificates that are saved at your router. Your router saves its own certificates, the certificate of the CA, and any RA certificates (unless you put the router into query mode as explained in the section [“Managing NVRAM Memory Usage”](#)).

To delete your router's certificate or RA certificates from your router's configuration, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router# show crypto ca certificates	Displays the certificates stored on your router; note (or copy) the serial number of the certificate you wish to delete.
Step 2	Router(config)# crypto ca certificate chain <i>name</i>	Enters certificate chain configuration mode.
Step 3	Router(config-cert-cha)# no certificate <i>certificate-serial-number</i>	Deletes the certificate.


To delete the CA's certificate, you must remove the entire CA identity, which also removes all certificates associated with the CA—your router's certificate, the CA certificate, and any RA certificates.

To remove a CA identity, use the following command in global configuration mode:

Command	Purpose
Router(config)# no crypto ca identity <i>name</i>	Deletes all identity information and certificates associated with the CA.

Viewing Keys and Certificates

To view keys and certificates, use the following commands in EXEC mode:

	Command	Purpose
Step 1	Router# show crypto key mypubkey rsa	Displays your router's RSA public keys.
Step 2	Router# show crypto key pubkey-chain rsa	Displays a list of all the RSA public keys stored on your router. These include the public keys of peers who have sent your router their certificates during peer authentication for IPSec.
Step 3	Router# show crypto key pubkey-chain rsa [<i>name key-name</i> <i>address key-address</i>]	Displays details of a particular RSA public key stored on your router.
Step 4	Router# show crypto ca certificates	Displays information about your certificate, the CA's certificate, and any RA certificates.
Step 5	Router# show crypto ca roots	Displays the CA roots configured in the router.
		 Note This command can be implemented only when multiple CAs are configured in the router.

What to Do Next

After you have finished configuring this feature, you should configure IKE and IPSec. IKE configuration is described in the chapter “Configuring Internet Key Exchange Security Protocol.” IPSec configuration is described in the chapter “Configuring IPSec Network Security.”

CA Interoperability Configuration Examples

The following configuration is for a router named “myrouter.” In this example, IPsec is configured and the IKE protocol and CA interoperability are configured in support of IPsec.

In this example, general-purpose RSA keys were generated, but you will notice that the keys are not saved or displayed in the configuration.

Comments are included within the configuration to explain various commands.

```
!
no service password-encryption
service udp-small-servers
service tcp-small-servers
!
! CA interoperability requires you to configure your router's hostname:
hostname myrouter
!
enable secret 5 <removed>
enable password <removed>
!
! CA interoperability requires you to configure your router's IP domain name:
ip domain-name example.com
ip name-server 172.29.2.132
ip name-server 192.168.30.32
!
! The following configures a transform set (part of IPsec configuration):
crypto ipsec transform-set my-transformset esp-3des esp-sha-hmac
!
! The following declares the CA. (In this example, the CA does not support an RA.)
crypto ca identity example.com
  enrollment url http://ca_server
!
! The following shows the certificates and CRLs stored at the router, including
! the CA certificate (shown first), the router's certificate (shown next)
! and a CRL (shown last).
crypto ca certificate chain example.com
! The following is the CA certificate
! received via the 'crypto ca authenticate' command:
certificate ca 3051DF7169BEE31B821DFE4B3A338E5F
  30820182 3082012C A0030201 02021030 51DF7169 BEE31B82 1DFE4B3A 338E5F30
  0D06092A 864886F7 0D010104 05003042 31163014 06035504 0A130D43 6973636F
  20537973 74656D73 3110300E 06035504 0B130744 65767465 73743116 30140603
  55040313 0D434953 434F4341 2D554C54 5241301E 170D3937 31323032 30313036
  32385A17 0D393831 32303230 31303632 385A3042 31163014 06035504 0A130D43
  6973636F 20537973 74656D73 3110300E 06035504 0B130744 65767465 73743116
  30140603 55040313 0D434953 434F4341 2D554C54 5241305C 300D0609 2A864886
  F70D0101 01050003 4B003048 024100C1 B69D7BF6 34E4EE28 A84E0DC6 FCA4DEA8
  04D89E50 C5EBE862 39D51890 D0D4B732 678BDBF2 80801430 E5E56E7C C126E2DD
  DBE9695A DF8E5BA7 E67BAE87 29375302 03010001 300D0609 2A864886 F70D0101
  04050003 410035AA 82B5A406 32489413 A7FF9A9A E349E5B4 74615E05 058BA3CE
  7C5F00B4 019552A5 E892D2A3 86763A1F 2852297F C68EECE1 F41E9A7B 2F38D02A
  B1D2F817 3F7B
quit
! The following is the router's certificate
! received via the 'crypto ca enroll' command:
certificate 7D28D4659D22C49134B3D1A0C2C9C8FC
  308201A6 30820150 A0030201 0202107D 28D4659D 22C49134 B3D1A0C2 C9C8FC30
  0D06092A 864886F7 0D010104 05003042 31163014 06035504 0A130D43 6973636F
  20537973 74656D73 3110300E 06035504 0B130744 65767465 73743116 30140603
  55040313 0D434953 434F4341 2D554C54 5241301E 170D3938 30343234 30303030
  30305A17 0D393930 34323432 33353935 395A302F 311D301B 06092A86 4886F70D
  01090216 0E73636F 742E6369 73636F2E 636F6D31 0E300C06 03550405 13053137
```



```
41464230 5C300D06 092A8648 86F70D01 01010500 034B0030 48024100 A207ED75
DE8A9BC4 980958B7 28ADF562 1371D043 1FC93C24 8E9F8384 4D1A2407 60CBD7EC
B15BD782 A687CA49 883369BE B35A4219 8FE742B0 91CF76EE 07EC9E69 02030100
01A33530 33300B06 03551D0F 04040302 05A03019 0603551D 11041230 10820E73
636F742E 63697363 6F2E636F 6D300906 03551D13 04023000 300D0609 2A864886
F70D0101 04050003 410085F8 A5AFA907 B38731A5 0195D921 D8C45EFD B6082C28
04A88CEC E9EC6927 F24874E4 30C4D7E2 2686E0B5 77F197E4 F82A8BA2 1E03944D
286B661F 0305DF5F 3CE7
quit
! The following is a CRL received by the router (via the router's own action):
crl
3081C530 71300D06 092A8648 86F70D01 01020500 30423116 30140603 55040A13
0D436973 636F2053 79737465 6D733110 300E0603 55040B13 07446576 74657374
31163014 06035504 03130D43 4953434F 43412D55 4C545241 170D3938 30333233
32333232 31305A17 0D393930 34323230 30303030 305A300D 06092A86 4886F70D
01010205 00034100 7AA83057 AC5E5C65 B9812549 37F11B7B 5CA4CAED 830B3955
A4DDD268 F567E29A E4B34691 C2162BD1 0540D7E6 5D6650D1 81DBBF1D 788F1DAC
BBF761B2 81FCC0F1
quit
!
! The following is an IPsec crypto map (part of IPsec configuration):
crypto map map-to-remotesite 10 ipsec-isakmp
set peer 172.21.114.196
set transform-set my-transformset
match address 124
!
!
interface Loopback0
ip address 10.0.0.1 255.0.0.0
!
interface Tunnel0
ip address 10.0.0.2 255.0.0.0
ip mtu 1490
no ip route-cache
no ip mroute-cache
tunnel source 10.10.0.1
tunnel destination 172.21.115.119
!
interface FastEthernet0/0
ip address 172.21.115.118 255.255.255.240
no ip mroute-cache
loopback
no keepalive
shutdown
media-type MII
full-duplex
!
! The IPsec crypto map is applied to interface Ethernet1/0:
interface Ethernet1/0
ip address 172.21.114.197 255.255.255.0
bandwidth 128
no keepalive
no fair-queue
no cdp enable
crypto map map-to-remotesite
```

```

!
crypto isakmp policy 15
  encryption 3des
  hash md5
  authentication rsa-sig
  group 2
  lifetime 5000
crypto isakmp policy 20
  authentication pre-share
  lifetime 10000
crypto isakmp key 1234567890 address 171.69.224.33

```

Multiple CAs Configuration Examples

The following examples show configuring multiple CAs (trusted roots) using SCEP or TFTP.

In this example, the configured trusted root is named “griffin”. The “griffin” trusted root is installed on the megatron server. The SCEP protocol and the root proxy URL are used to obtain the root certificate.

```

crypto ca trusted-root griffin
  root SCEP http://griffin:80
  root proxy http://megatron:8080
!
crypto ca authenticate griffin
Root certificate MD5 finger print:
8B4EC8C1 9308376F A0253C2A 34112AA6
% Do you accept this certificate? [yes/no]:y

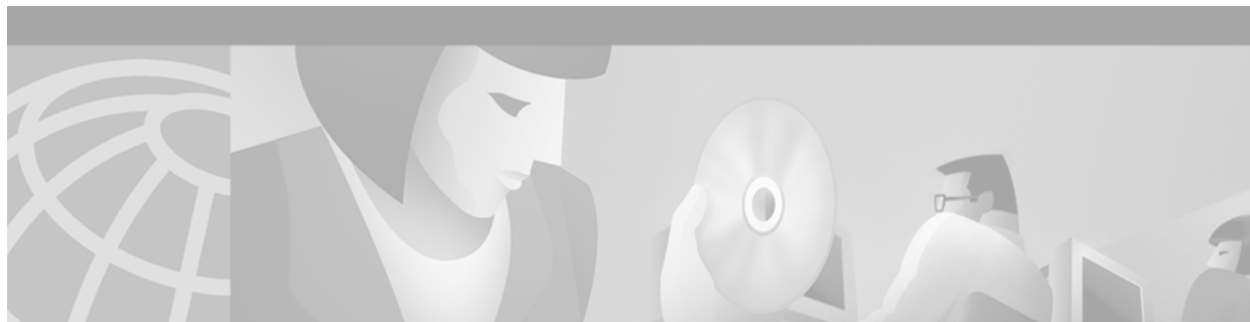
```

In this example, the configured trusted root is named “banana”. Using TFTP, “banana” is installed on the “strawberry” server, and the filename is ca-cert/banana.

```

crypto ca trusted-root banana
  root tftp strawberry ca-cert/banana
!
crypto ca authenticate banana
Loading ca-cert/banana from 10.4.9.10 (via Ethernet0):!
[OK - 785/4096 bytes]
!
! Root certificate MD5 finger print:
F3F53FFB 925D052F 0C801EE7 89774ED3
% Do you accept this certificate? [yes/no]:y
Root certificate accepted.

```



Configuring Internet Key Exchange Security Protocol

This chapter describes how to configure the Internet Key Exchange (IKE) protocol. IKE is a key management protocol standard that is used in conjunction with the IPSec standard. IPSec is an IP security feature that provides robust authentication and encryption of IP packets.

IPSec can be configured without IKE, but IKE enhances IPSec by providing additional features, flexibility, and ease of configuration for the IPSec standard.

IKE is a hybrid protocol that implements the Oakley key exchange and the Skeme key exchange inside the Internet Security Association and Key Management Protocol (ISAKMP) framework. (ISAKMP, Oakley, and Skeme are security protocols implemented by IKE.)

For a complete description of the IKE commands used in this chapter, refer to the “Internet Key Exchange Security Protocol Commands” chapter in the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the “Identifying Supported Platforms” section in the chapter “Using Cisco IOS Software.”

In This Chapter

This chapter includes the following sections:

- [About IKE](#)
- [IKE Configuration Task List](#)
- [What To Do Next](#)
- [IKE Configuration Examples](#)

About IKE

IKE automatically negotiates IPSec security associations (SAs) and enables IPSec secure communications without costly manual preconfiguration. Specifically, IKE provides these benefits:

- Eliminates the need to manually specify all the IPSec security parameters in the crypto maps at both peers.
- Allows you to specify a lifetime for the IPSec security association.
- Allows encryption keys to change during IPSec sessions.
- Allows IPSec to provide anti-replay services.
- Permits certification authority (CA) support for a manageable, scalable IPSec implementation.
- Allows dynamic authentication of peers.

This section includes the following sections:

- [Supported Standards](#)
- [List of Terms](#)
- [IKE Aggressive Mode Behavior](#)

Supported Standards

Cisco implements the following standards:

- IKE—Internet Key Exchange. A hybrid protocol that implements Oakley and Skeme key exchanges inside the ISAKMP framework. IKE can be used with other protocols, but its initial implementation is with the IPSec protocol. IKE provides authentication of the IPSec peers, negotiates IPSec keys, and negotiates IPSec security associations.

IKE is implemented in accordance with RFC 2409, *The Internet Key Exchange*.

- IPSec—IP Security Protocol. IPSec is a framework of open standards that provides data confidentiality, data integrity, and data authentication between participating peers. IPSec provides these security services at the IP layer; it uses IKE to handle negotiation of protocols and algorithms based on local policy and to generate the encryption and authentication keys to be used by IPSec. IPSec can be used to protect one or more data flows between a pair of hosts, between a pair of security gateways, or between a security gateway and a host.

For more information on IPSec, see the chapter “Configuring IPSec Network Security.”

- ISAKMP—Internet Security Association and Key Management Protocol. A protocol framework that defines payload formats, the mechanics of implementing a key exchange protocol, and the negotiation of a security association.

ISAKMP is implemented in accordance with the latest version of the *Internet Security Association and Key Management Protocol (ISAKMP)* Internet Draft (RFC 2408).

- Oakley—A key exchange protocol that defines how to derive authenticated keying material.
- Skeme—A key exchange protocol that defines how to derive authenticated keying material, with rapid key refreshment.

The component technologies implemented for use by IKE include the following:

- **DES**—Data Encryption Standard. An algorithm that is used to encrypt packet data. IKE implements the 56-bit DES-CBC with Explicit IV standard. Cipher Block Chaining (CBC) requires an initialization vector (IV) to start encryption. The IV is explicitly given in the IPSec packet.

Cisco IOS software also implements Triple DES (168-bit) encryption, depending on the software versions available for a specific platform. Triple DES (3DES) is a strong form of encryption that allows sensitive information to be transmitted over untrusted networks. It enables customers, particularly in the finance industry, to utilize network-layer encryption.

**Note**

Cisco IOS images that have strong encryption (including, but not limited to, 56-bit data encryption feature sets) are subject to United States government export controls, and have a limited distribution. Images that are to be installed outside the United States require an export license. Customer orders might be denied or subject to delay because of United States government regulations. Contact your sales representative or distributor for more information, or send e-mail to export@cisco.com.

- **Diffie-Hellman**—A public-key cryptography protocol that allows two parties to establish a shared secret over an unsecure communications channel. Diffie-Hellman is used within IKE to establish session keys. 768-bit and 1024-bit Diffie-Hellman groups are supported.
- **MD5 (HMAC variant)**—Message Digest 5. A hash algorithm used to authenticate packet data. HMAC is a variant that provides an additional level of hashing.
- **SHA (HMAC variant)**—Secure Hash Algorithm. A hash algorithm used to authenticate packet data. HMAC is a variant that provides an additional level of hashing.
- **RSA signatures and RSA encrypted nonces**—RSA is the public key cryptographic system developed by Ron Rivest, Adi Shamir, and Leonard Adleman. RSA signatures provide nonrepudiation, and RSA encrypted nonces provide repudiation. (Repudiation and nonrepudiation have to do with traceability.)

IKE interoperates with the following standard:

X.509v3 certificates—Used with the IKE protocol when authentication requires public keys. This certificate support allows the protected network to scale by providing the equivalent of a digital ID card to each device. When two devices wish to communicate, they exchange digital certificates to prove their identity (thus removing the need to manually exchange public keys with each peer or to manually specify a shared key at each peer).

List of Terms

Anti-Replay

Anti-replay is a security service in which the receiver can reject old or duplicate packets in order to protect itself against replay attacks. IPSec provides optional anti-replay services by use of a sequence number combined with the use of authentication.

Data Authentication

Data authentication includes two concepts:

- **Data integrity** (verifying that data has not been altered)
- **Data origin authentication** (verifying that the data was actually sent by the claimed sender)

Data authentication can refer either to integrity alone or to both of these concepts (although data origin authentication is dependent upon data integrity).

Peer

In the context of this chapter, “peer” refers to a router or other device that participates in IPSec and IKE.

Perfect Forward Secrecy

Perfect forward secrecy (PFS) is a cryptographic characteristic associated with a derived shared secret value. With PFS, if one key is compromised, previous and subsequent keys are not also compromised, because subsequent keys are not derived from previous keys.

Repudiation

Repudiation is a quality that prevents a third party from being able to prove that a communication between two other parties ever took place. This is a desirable quality if you do not want your communications to be traceable. **Nonrepudiation** is the opposite quality—a third party can prove that a communication between two other parties took place. Nonrepudiation is desirable if you want to be able to trace your communications and prove that they occurred.

Security Association

A security association (SA) describes how two or more entities will utilize security services to communicate securely. For example, an IPSec SA defines the encryption algorithm (if used), the authentication algorithm, and the shared session key to be used during the IPSec connection.

Both IPSec and IKE require and use SAs to identify the parameters of their connections. IKE can negotiate and establish its own SA. The IPSec SA is established either by IKE or by manual user configuration.

IKE Aggressive Mode Behavior

This section describes IKE aggressive mode behavior occurring when Cisco IOS software is used.

IKE has two phases of key negotiation: phase 1 and phase 2. Phase 1 negotiates a security association (a key) between two IKE peers. The key negotiated in phase 1 enables IKE peers to communicate securely in phase 2. During phase 2 negotiation, IKE establishes keys (security associations) for other applications, such as IPSec.

Phase 1 negotiation can occur using one of two modes: main mode and aggressive mode. Main mode tries to protect all information during the negotiation, meaning that no information is available to a potential attacker. When main mode is used, the identities of the two sides are hidden. Although this mode of operation is very secure, it is relatively costly in terms of the time it takes to complete the negotiation. Aggressive mode takes less time to negotiate keys between peers; however, it gives up some of the security provided by main mode negotiation. For example, the identities of the two parties trying to establish a security association are exposed to an eavesdropper.

The two modes serve different purposes and have different strengths. Main mode is slower than aggressive mode, but main mode is more secure and more flexible because it can offer an IKE peer more security proposals than aggressive mode. Aggressive mode is less flexible and not as secure, but much faster.

In Cisco IOS software, the two modes are not configurable. The default action for IKE authentication (rsa-sig, rsa-encr, or preshared) is to initiate main mode; however, in cases where there is no corresponding information to initiate authentication, and there is a preshared key associated with the host name of the peer, Cisco IOS software can initiate aggressive mode. Cisco IOS software will respond in aggressive mode to an IKE peer that initiates aggressive mode.

Whether Cisco IOS software initiates main mode or aggressive mode, the following restrictions are applicable:

- The initiating router *must not* have a certificate associated with the remote peer.
- The preshared key *must* be by fully qualified domain name (FQDN) on both peers.; thus, you have to enter the **crypto isakmp key *keystring* *hostname* *peer-address*** command in configuration mode.
- The communicating routers *must* have a FQDN host entry for each other in their configurations.
- The communicating routers *must* be configured to authenticate by hostname, *not* by IP address; thus, you should use the **crypto isakmp identity *hostname*** command.

IKE Configuration Task List

To configure IKE, perform the tasks in the following sections. The tasks in the first three sections are required; the remaining may be optional, depending on what parameters are configured.

- [Enabling or Disabling IKE](#) (Required)
- [Ensuring That Access Lists Are Compatible with IKE](#) (Required)
- [Creating IKE Policies](#) (Required)
- [Manually Configuring RSA Keys](#) (Optional, depending on IKE parameters)
- [Configuring Preshared Keys](#) (Optional, depending on IKE parameters)
- [Configuring Mask Preshared Keys](#) (Optional, depending on IKE parameters)
- [Configuring Preshared Keys Using a AAA Server](#) (Optional, depending on IKE parameters)
- [Configuring Internet Key Exchange Mode Configuration](#) (Optional)
- [Configuring Internet Key Exchange Extended Authentication \(Xauth\)](#) (Optional)
- [Configuring Tunnel Endpoint Discovery \(TED\)](#) (Optional)
- [Clearing IKE Connections](#) (Optional)
- [Troubleshooting IKE](#) (Optional)

For IKE configuration examples, refer to the section “[IKE Configuration Examples](#)” at the end of this chapter.

Enabling or Disabling IKE

IKE is enabled by default. IKE does not have to be enabled for individual interfaces, but it is enabled globally for all interfaces at the router.

If you do not want IKE to be used with your IPSec implementation, you can disable it at all IPSec peers.

If you disable IKE, you will have to make these concessions at the peers:

- You must manually specify all the IPSec security associations in the crypto maps at all peers. (Crypto map configuration is described in the chapter “Configuring IPSec Network Security.”)
- The IPSec security associations of the peers will never time out for a given IPSec session.
- During IPSec sessions between the peers, the encryption keys will never change.
- Anti-replay services will not be available between the peers.
- Certification authority (CA) support cannot be used.

To disable or enable IKE, use one of the following commands in global configuration mode:

Command	Purpose
Router(config)# no crypto isakmp enable	Disables IKE.
Router(config)# crypto isakmp enable	Enables IKE.

If you disable IKE, you can skip the rest of the tasks in this chapter and go directly to IPSec configuration, as described in the chapter “Configuring IPSec Network Security.”

Ensuring That Access Lists Are Compatible with IKE

IKE negotiation uses UDP on port 500. Ensure that your access lists are configured so that UDP port 500 traffic is not blocked at interfaces used by IKE and IPSec. In some cases you might need to add a statement to your access lists to explicitly permit UDP port 500 traffic.

Creating IKE Policies

You must create IKE policies at each peer. An IKE policy defines a combination of security parameters to be used during the IKE negotiation.

To create an IKE policy, follow the guidelines in these sections:

- [Why Do You Need to Create These Policies?](#)
- [What Parameters Do You Define in a Policy?](#)
- [How Do IKE Peers Agree upon a Matching Policy?](#)
- [Which Value Should You Select for Each Parameter?](#)
- [Creating Policies](#)
- [Additional Configuration Required for IKE Policies](#)

Why Do You Need to Create These Policies?

IKE negotiations must be protected, so each IKE negotiation begins by agreement of both peers on a common (shared) IKE policy. This policy states which security parameters will be used to protect subsequent IKE negotiations and mandates how the peers are authenticated.

After the two peers agree upon a policy, the security parameters of the policy are identified by a security association established at each peer, and these security associations apply to all subsequent IKE traffic during the negotiation.

You can create multiple, prioritized policies at each peer to ensure that at least one policy will match the policy of a remote peer.

What Parameters Do You Define in a Policy?

There are five parameters to define in each IKE policy:

Parameter	Accepted Values	Keyword	Default Value
encryption algorithm	56-bit DES-CBC	des	56-bit DES-CBC
	168-bit DES	3des	168-bit DES
hash algorithm	SHA-1 (HMAC variant)	sha	SHA-1
	MD5 (HMAC variant)	md5	
authentication method	RSA signatures	rsa-sig	RSA signatures
	RSA encrypted nonces	rsa-encr	
	preshared keys	pre-share	
Diffie-Hellman group identifier	768-bit Diffie-Hellman or 1024-bit Diffie-Hellman	1 2	768-bit Diffie-Hellman
lifetime of the security association ¹	Any number of seconds	—	86400 seconds (one day)

1. For information about this lifetime and how it is used, see the command description for the **lifetime** command.

These parameters apply to the IKE negotiations when the IKE security association is established.

How Do IKE Peers Agree upon a Matching Policy?

When the IKE negotiation begins, IKE looks for an IKE policy that is the same on both peers. The peer that initiates the negotiation will send all its policies to the remote peer, and the remote peer will try to find a match. The remote peer looks for a match by comparing its own highest priority policy against the policies received from the other peer. The remote peer checks each of its policies in order of its priority (highest priority first) until a match is found.

A match is made when both policies from the two peers contain the same encryption, hash, authentication, and Diffie-Hellman parameter values, and when the remote peer's policy specifies a lifetime that is less than or equal to the lifetime in the policy being compared. (If the lifetimes are not identical, the shorter lifetime—from the remote peer's policy—will be used.)

If no acceptable match is found, IKE refuses negotiation and IPSec will not be established.

If a match is found, IKE will complete negotiation, and IPSec security associations will be created.



Note

Depending on which authentication method is specified in a policy, additional configuration might be required (as described in the section “[Additional Configuration Required for IKE Policies](#)”). If a peer's policy does not have the required companion configuration, the peer will not submit the policy when attempting to find a matching policy with the remote peer.

Which Value Should You Select for Each Parameter?

You can select certain values for each parameter, in accordance with the IKE standard. But why choose one value over another?

If you are interoperating with a device that supports only one of the values for a parameter, your choice is limited to the value supported by the other device. Aside from this, there is often a trade-off between security and performance, and many of these parameter values represent such a trade-off. You should evaluate the level of security risks for your network and your tolerance for these risks. Then the following tips might help you select which value to specify for each parameter:

- The encryption algorithm has two options: 56-bit DES-CBC and 168-bit DES.
- The hash algorithm has two options: SHA-1 and MD5.

MD5 has a smaller digest and is considered to be slightly faster than SHA-1. There has been a demonstrated successful (but extremely difficult) attack against MD5; however, the HMAC variant used by IKE prevents this attack.

- The authentication method has three options: RSA signatures, RSA encrypted nonces, and preshared keys.
 - RSA signatures provide nonrepudiation for the IKE negotiation (you can prove to a third party after the fact that you did indeed have an IKE negotiation with the remote peer).

RSA signatures allow the use of a certification authority (CA). Using a CA can dramatically improve the manageability and scalability of your IPSec network. Additionally, RSA signature-based authentication uses only two public key operations, whereas RSA encryption uses four public key operations, making it costlier in terms of overall performance.

You can also exchange the public keys manually, as described in section “[Manually Configuring RSA Keys](#).”

- RSA encrypted nonces provide repudiation for the IKE negotiation (you cannot prove to a third party that you had an IKE negotiation with the remote peer).

RSA encrypted nonces require that peers possess each other’s public keys but do not use a certification authority. Instead, there are two ways for peers to get each other’s public keys:

1) During configuration you manually configure RSA keys (as described in the section “[Manually Configuring RSA Keys](#)”).

2) If your local peer has previously used RSA signatures with certificates during a successful IKE negotiation with a remote peer, your local peer already possesses the remote peer’s public key. (The peers’ public keys are exchanged during the RSA-signatures-based IKE negotiations, if certificates are used.)

- Preshared keys are clumsy to use if your secured network is large, and they do not scale well with a growing network. However, they do not require use of a certification authority, as do RSA signatures, and might be easier to set up in a small network with fewer than 10 nodes. RSA signatures also can be considered more secure when compared with preshared key authentication.
- The Diffie-Hellman group identifier has two options: 768-bit and 1024-bit Diffie-Hellman. The 1024-bit Diffie-Hellman option is harder to crack, but requires more CPU time to execute.
- The lifetime of the security association can be set to any value.

As a general rule, the shorter the lifetime (up to a point), the more secure your IKE negotiations will be. However, with longer lifetimes, future IPSec security associations can be set up more quickly. For more information about this parameter and how it is used, see the command description for the **lifetime** command.

Creating Policies

You can create multiple IKE policies, each with a different combination of parameter values. For each policy that you create, you assign a unique priority (1 through 10,000, with 1 being the highest priority).

You can configure multiple policies on each peer—but at least one of these policies must contain exactly the same encryption, hash, authentication, and Diffie-Hellman parameter values as one of the policies on the remote peer. (The lifetime parameter does not necessarily have to be the same; see details in the section “[How Do IKE Peers Agree upon a Matching Policy?](#)”)

If you do not configure any policies, your router will use the default policy, which is always set to the lowest priority, and which contains the default value of each parameter.

To configure a policy, use the following commands, beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto isakmp policy <i>priority</i>	Identifies the policy to create. (Each policy is uniquely identified by the priority number you assign.) (This command puts you into the config-isakmp command mode.)
Step 2	Router(config-isakmp)# encryption { <i>des</i> <i>3des</i> }	Specifies the encryption algorithm.
Step 3	Router(config-isakmp)# hash { <i>sha</i> <i>md5</i> }	Specifies the hash algorithm.
Step 4	Router(config-isakmp)# authentication { <i>rsa-sig</i> <i>rsa-encr</i> <i>pre-share</i> }	Specifies the authentication method.
Step 5	Router(config-isakmp)# group { <i>1</i> <i>2</i> }	Specifies the Diffie-Hellman group identifier.
Step 6	Router(config-isakmp)# lifetime <i>seconds</i>	Specifies the lifetime of the security association.
Step 7	Router(config-isakmp)# exit	Exits the config-isakmp command mode.
Step 8	Router(config)# exit	Exits the global configuration mode.
Step 9	Router# show crypto isakmp policy	(Optional) Displays all existing IKE policies. (Use this command in EXEC mode.)

If you do not specify a value for a parameter, the default value is assigned.



Note

The default policy and the default values for configured policies do not show up in the configuration when you issue a **show running** command. Instead, to see the default policy and any default values within configured policies, use the **show crypto isakmp policy** command.

Additional Configuration Required for IKE Policies

Depending on which authentication method you specify in your IKE policies, you must do certain additional configuration tasks before IKE and IPSec can successfully use the IKE policies.

Each authentication method requires additional companion configuration as follows:

- RSA signatures method:

If you specify RSA signatures as the authentication method in a policy, you may configure the peers to obtain certificates from a certification authority (CA). (The CA must be properly configured to issue the certificates.) Configure this certificate support as described in the chapter “Configuring Certification Authority Interoperability.”

The certificates are used by each peer to exchange public keys securely. (RSA signatures requires that each peer has the public signature key of the remote peer.) When both peers have valid certificates, they will automatically exchange public keys with each other as part of any IKE negotiation in which RSA signatures are used.

You may also wish to exchange the public keys manually, as described in the section “[Manually Configuring RSA Keys](#).”

- RSA encrypted nonces method:

If you specify RSA encrypted nonces as the authentication method in a policy, you must ensure that each peer has the public keys of the other peers.

Unlike RSA signatures, the RSA encrypted nonces method can not use certificates to exchange public keys. Instead, you ensure that each peer has the others’ public keys by one of the following methods:

- Manually configuring RSA keys as described in the section “[Manually Configuring RSA Keys](#).”
or
- Ensuring that an IKE exchange using RSA signatures with certificates has already occurred between the peers. (The peers’ public keys are exchanged during the RSA-signatures-based IKE negotiations if certificates are used.)

To make this happen, specify two policies: a higher-priority policy with RSA encrypted nonces and a lower-priority policy with RSA signatures. When IKE negotiations occur, RSA signatures will be used the first time because the peers do not yet have each other’s public keys. Then future IKE negotiations will be able to use RSA encrypted nonces because the public keys will have been exchanged.

This alternative requires that you have certification authority support configured.

- Preshared keys authentication method:

If you specify preshared keys as the authentication method in a policy, you must configure these preshared keys as described in the section “[Configuring Preshared Keys](#).”

If RSA encryption is configured and signature mode is negotiated (and certificates are used for signature mode), the peer will request both signature and encryption keys. Basically, the router will request as many keys as the configuration will support. If RSA encryption is not configured, it will just request a signature key.

Manually Configuring RSA Keys

Manually configure RSA keys when you specify RSA encrypted nonces as the authentication method in an IKE policy and you are not using a certification authority (CA).

To manually configure RSA keys, perform these tasks at each IPSec peer that uses RSA encrypted nonces in an IKE policy:

- [Generating RSA Keys](#)
- [Setting ISAKMP Identity](#)
- [Specifying RSA Public Keys of All the Other Peers](#)

Generating RSA Keys

To generate RSA keys, use the following commands starting in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto key generate rsa [usage-keys]	Generates RSA keys.
Step 2	Router# show crypto key mypubkey rsa	Displays the generated RSA public key (in EXEC mode).

Remember to repeat these tasks at each peer (without CA support) that uses RSA encrypted nonces in an IKE policy.

Setting ISAKMP Identity

You should set the ISAKMP identity for each peer that uses preshared keys in an IKE policy.

When two peers use IKE to establish IPsec security associations, each peer sends its identity to the remote peer. Each peer sends either its host name or its IP address, depending on how you have set the ISAKMP identity of the router.

By default, a peer's ISAKMP identity is the IP address of the peer. If appropriate, you could change the identity to be the peer's host name instead. As a general rule, set the identities of all peers the same way—either all peers should use their IP addresses or all peers should use their host names. If some peers use their host names and some peers use their IP addresses to identify themselves to each other, IKE negotiations could fail if the identity of a remote peer is not recognized and a DNS lookup is unable to resolve the identity.

To set the ISAKMP identity of a peer, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto isakmp identity {address hostname}	At the local peer: Specifies the peer's ISAKMP identity by IP address or by host name. ¹
Step 2	Router(config)# ip host hostname address1 [address2...address8]	At all remote peers: If the local peer's ISAKMP identity was specified using a host name, maps the peer's host name to its IP address(es) at all the remote peers. (This step might be unnecessary if the host name or address is already mapped in a DNS server.)

1. See the **crypto isakmp identity** command description for guidelines for when to use the IP address and when to use the host name.

Remember to repeat these tasks at each peer that uses preshared keys in an IKE policy.

Specifying RSA Public Keys of All the Other Peers

At each peer, specify the RSA public keys of all the other peers by using the following commands starting in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto key pubkey-chain rsa	Enters public key chain configuration mode.
Step 2	Router(config-pubkey-c)# named-key <i>key-name</i> [encryption signature] or Router (config-pubkey-c)# addressed-key <i>key-address</i> [encryption signature]	Indicates which remote peer's RSA public key you are going to specify. Enters public key configuration mode. If the remote peer uses its host name as its ISAKMP identity, use the named-key command and specify the remote peer's fully qualified domain name (such as somerouter.example.com) as the <i>key-name</i> . If the remote peer uses its IP address as its ISAKMP identity, use the addressed-key command and specify the remote peer's IP address as the <i>key-address</i> .
Step 3	Router(config-pubkey-k)# address <i>ip-address</i>	Specifies the remote peer's IP address. You can optionally use this command if you used a fully qualified domain name to name the remote peer in Step 2 (using the named-key command).
Step 4	Router(config-pubkey-k)# key-string <i>key-string</i>	Specifies the remote peer's RSA public key. This is the key previously viewed by the remote peer's administrator when the remote router's RSA keys were generated.
Step 5	Router(config-pubkey-k)# quit	Returns to public key chain configuration mode.
Step 6	—	Repeat Steps 2 through 4 to specify the RSA public keys of all the other IPSec peers that use RSA encrypted nonces in an IKE policy.
Step 7	Router(config-pubkey-c)# exit	Returns to global configuration mode.

Remember to repeat these tasks at each peer that uses RSA encrypted nonces in an IKE policy.

To view RSA public keys while or after you configure them, use the following command in EXEC mode:

Command	Purpose
Router# show crypto key pubkey-chain rsa { name <i>key-name</i> address <i>key-address</i> }	Displays a list of all the RSA public keys stored on your router, or displays details of a particular RSA public key stored on your router.

Configuring Preshared Keys

To configure preshared keys, perform these tasks at each peer that uses preshared keys in an IKE policy:

- First, set the ISAKMP identity of each peer. Each peer's identity should be set to either its host name or by its IP address. By default, a peer's identity is set to its IP address. Setting ISAKMP identities is described in the section "[Setting ISAKMP Identity](#)."
- Next, specify the shared keys at each peer. Note that a given preshared key is shared between two peers. At a given peer you could specify the same key to share with multiple remote peers; however, a more secure approach is to specify different keys to share between different pairs of peers.

To specify preshared keys at a peer, use the following commands in global configuration mode:

	Command	Purpose
Step 1	Router(config)# crypto isakmp key <i>keystring</i> address <i>peer-address</i>	At the local peer: Specifies the shared key to be used with a particular remote peer.
	or Router(config)# crypto isakmp key <i>keystring</i> hostname <i>peer-hostname</i>	If the remote peer specified its ISAKMP identity with an address, use the address keyword in this step; otherwise use the hostname keyword in this step.
Step 2	Router(config)# crypto isakmp key <i>keystring</i> address <i>peer-address</i>	At the remote peer: Specifies the shared key to be used with the local peer. This is the same key you just specified at the local peer.
	or Router(config)# crypto isakmp key <i>keystring</i> hostname <i>peer-hostname</i>	If the local peer specified its ISAKMP identity with an address, use the address keyword in this step; otherwise use the hostname keyword in this step.
Step 3	—	Repeat Steps 1 and 2 for each remote peer.

Remember to repeat these tasks at each peer that uses preshared keys in an IKE policy.

Configuring Mask Preshared Keys

A mask preshared key allows a group of remote users with the same level of authentication to share an IKE preshared key. The preshared key of the remote peer must match the preshared key of the local peer for IKE authentication to occur.

A mask preshared key is usually distributed through a secure out-of-band channel. In a remote peer-to-local peer scenario, any remote peer with the IKE preshared key configured can establish IKE SAs with the local peer.

If you specify the *mask* argument with the **crypto isakmp key** command, it is up to you to use a subnet address, which will allow more peers to share the same key. That is, the preshared key is no longer restricted to use between two users.



Note

Using 0.0.0.0 as a subnet address is not recommended because it encourages group preshared keys, which allow all peers to have the same group key, thereby reducing the security of your user authentication.

Mask preshared keys have the following restrictions:

- The SA cannot be established between the IPSec peers until all IPSec peers are configured for the same preshared key.
- The mask preshared key must be distinctly different for remote users requiring varying levels of authorization. You must configure a new preshared key for each level of trust and assign the correct keys to the correct parties. Otherwise, an untrusted party may obtain access to protected data.

Before configuring mask preshared keys, perform the tasks listed in the section “[Configuring Preshared Keys](#).”

To configure mask preshared key at each peer, use the following command in global configuration mode:

Command	Purpose
Router(config)# crypto isakmp key <i>keystring</i> address <i>peer-address</i> [<i>mask</i>]	<p>At the local peer: Specifies the shared key to be used with a particular remote peer and the mask IP address.</p> <p>At the local peer: Specifies the shared key to be used with the local peer and the mask IP address.</p> <p>Note If you specify a mask, it is up to you to use a subnet address.</p>

Configuring Preshared Keys Using a AAA Server

Preshared keys do not scale well when you are trying to deploy a large scale VPN without using a CA. When dynamic IP addressing such as DHCP or PPP dialups is used, the changing IP address can make key lookup difficult or impossible unless a mask preshared key is used. However, mask preshared keys are not very secure because a large number of users are given the same secret, thus reducing the security of the secret.

Configuring preshared keys using a AAA server allows each user to have his or her own key, which is stored on an external AAA server. This allows for central management of the user database, linking it to an existing AAA database, in addition to allowing every user to have a unique, more secure preshared key.

Preshared keys using a AAA server have the following restrictions:

- The shared secret can be accessed only in aggressive mode. The ID of the IKE exchange is used as the username to query AAA if no local key can be found on the Cisco IOS router to which the user is trying to connect. Aggressive mode provides the ID in the first part of the IKE exchange; main mode does not provide the ID until the latter part of the IKE exchange, which is too late for key lookup.
- Only the following ID types can be used:
 - IPV4 Address (can be different from the one assigned by the ISP)
 - FQDN (fully qualified domain name)
 - E-mail address

To configure this feature, perform the following tasks at each peer:

- Configure AAA.
- Configure an IPSec transform set.

- Configure a static crypto map.
- Configure extended authentication. (Optional)
- Configure ISAKMP policy.
- Configure a dynamic crypto map.

For information on configuring IPSec transform sets and crypto maps, refer to the chapter “Configuring IPSec Network Security.”

To enable an IPSec peer for preshared keys using a AAA server, perform the following task in crypto map configuration mode:

Command	Purpose
Router(config-crypto-map)# crypto map <i>map-name</i> isakmp authorization list <i>list-name</i>	Enables IKE querying of AAA for tunnel attributes in aggressive mode.

Configuring Internet Key Exchange Mode Configuration

Internet Key Exchange (IKE) Mode Configuration, as defined by the Internet Engineering Task Force (IETF), allows a gateway to download an IP address (and other network level configuration) to the client as part of an IKE negotiation. Using this exchange, the gateway gives IP addresses to the IKE client to be used as an “inner” IP address encapsulated under IPSec. This method provides a known IP address for the client that can be matched against Internet Protocol Security (IPSec) policy.

To implement IPSec Virtual Private Networks (VPNs) between remote access clients that have dynamic IP addresses and a corporate gateway, you have to dynamically administer scalable IPSec policy on the gateway once each client is authenticated. With IKE Mode Configuration, the gateway can set up scalable policy for a very large set of clients irrespective of the IP addresses of those clients.

There are two types of IKE Mode Configuration:

- Gateway initiation—Gateway initiates the configuration mode with the client. Once the client responds, the IKE modifies the identity of the sender, the message is processed, and the client receives a response.
- Client initiation—Client initiates the configuration mode with the gateway. The gateway responds with an IP address that it has allocated for the client.

IKE Mode Configuration has the following restrictions:

- Interfaces with crypto maps that are configured for IKE Mode Configuration may experience a slightly longer connection setup time. This is true even for IKE peers that refuse to be configured or do not respond to the configuration mode request. In both cases, the gateway initiates the configuration of the client.
- This feature was not designed to enable the configuration mode for every IKE connection by default. Configure this feature at the global crypto map level.
- The following items in the IETF draft are not currently supported:
 - Configuration attributes other than INTERNAL_IP_ADDRESS
 - Unprotected exchanges

There are two steps to configuring IKE Mode Configuration on a router:

1. Define the pool of IP addresses.
2. Define which crypto maps should attempt to configure clients.

To configure IKE Mode Configuration on your Cisco access router, use the following commands in global configuration mode:

	Command	Purpose
Step 1	<code>router(config)# ip local pool pool-name start-addr end-addr</code>	Defines an existing local address pool that defines a set of addresses. For more information on the ip local pool command, refer to the <i>Cisco IOS Dial Technologies Command Reference</i> .
Step 2	<code>router(config)# crypto isakmp client configuration address-pool local pool-name</code>	References the local address pool in the IKE configuration. For more information on the crypto isakmp client configuration address-pool local command, refer to the <i>Cisco IOS Security Command Reference</i> .
Step 3	<code>router(config)# crypto map tag client configuration address [initiate respond]</code>	Configures IKE Mode Configuration in global crypto map configuration mode. For more information on the crypto map client configuration address command, refer to the <i>Cisco IOS Security Command Reference</i> .

Configuring Internet Key Exchange Extended Authentication (Xauth)

IKE Extended Authentication (Xauth) is a draft RFC based on the IKE protocol. Xauth allows all Cisco IOS software AAA authentication methods to perform user authentication in a separate phase after the IKE authentication phase 1 exchange. The AAA configuration list name must match the Xauth configuration list name for user authentication to occur.

Xauth does not replace IKE. IKE allows for device authentication and Xauth allows for user authentication, which occurs after IKE device authentication. Xauth occurs after IKE authentication phase 1, but before IKE IPSec SA negotiation phase 2.

To configure Xauth, perform the following tasks:

- Configure AAA (You must set up an authentication list.)
- Configure an IPSec transform
- Configure a static crypto map
- Configure ISAKMP policy
- Configure a dynamic crypto map (Optional)

For information on configuring IPSec transform sets and crypto maps, refer to the chapter “Configuring IPSec Network Security.”

To enable Xauth on a crypto map, perform the following task in crypto map configuration mode:

Command	Purpose
Router(config)# crypto map <i>map-name</i> client authentication list <i>list-name</i>	<p>Enables extended authentication (Xauth) on a crypto map.</p> <p>Note After enabling Xauth, you should apply the crypto map on which Xauth is configured to the router interface.</p>

To verify that the Xauth feature is enabled, use the **show crypto map** command in EXEC mode. If the **crypto map client authentication list** command does not appear in the crypto map output, the Xauth feature is not enabled.

Configuring Tunnel Endpoint Discovery (TED)

Tunnel Endpoint Discovery (TED) is an enhancement to the IPSec feature. Defining a dynamic crypto map allows you to be able to dynamically determine an IPSec peer; however, only the receiving router has this ability. With TED, the initiating router can dynamically determine an IPSec peer for secure IPSec communications.

Dynamic TED helps to simplify IPSec configuration on the individual routers within a large network. Each node has a simple configuration that defines the local network that the router is protecting and the required IPSec transforms.

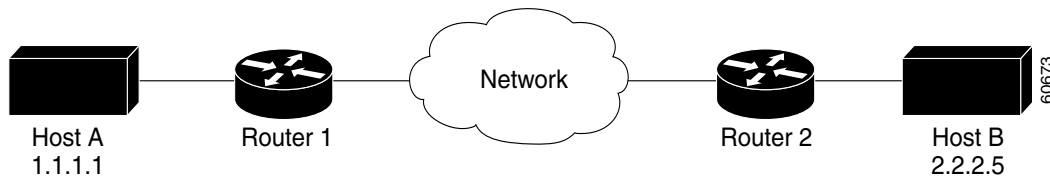
To have a large, fully-meshed network *without* TED, each peer needs to have static crypto maps to every other peer in the network. For example, if there are 100 peers in a large, fully-meshed network, each router needs 99 static crypto maps for each of its peers. With TED, only a single dynamic crypto map with TED enabled is needed because the peer is discovered dynamically. Thus, static crypto maps do not need to be configured for each peer.



Note

TED helps only in discovering peers; otherwise, TED does not function any differently than normal IPSec. TED does not improve the scalability of IPSec (in terms of performance or the number of peers or tunnels).

[Figure 36](#) and the corresponding steps explain a sample TED network topology.

Figure 36 Tunnel Endpoint Discovery Sample Network Topology

-
- Step 1** Host A sends a packet that is destined for Host B.
- Step 2** Router 1 intercepts and reads the packet. According to the IKE policy, Router 1 contains the following information: the packet must be encrypted, there are no SAs for the packet, and TED is enabled. Thus, Router 1 drops the packet and sends a TED probe into the network. (The TED probe contains the IP address of Host A (as the source IP address) and the IP address of Host B (as the destination IP address) embedded in the payload.)
- Step 3** Router 2 intercepts the TED probe and checks the probe against the ACLs that it protects; after the probe matches an ACL, it is recognized as a TED probe for proxies that the router protects. It then sends a TED reply with the IP address of Host B (as the source IP address) and the IP address of Host A (as the destination IP address) embedded in the payload.
- Step 4** Router 1 intercepts the TED reply and checks the payloads for the IP address and half proxy of Router 2. It then combines the source side of its proxy with the proxy found in the second payload and initiates an IKE session with Router 2; thereafter, Router 1 initiates an IPSec session with Router 2.
-



Note IKE cannot occur until the peer is identified.

TED Versions

The following table lists the available TED versions:

Version	First Available Release	Description
TEDv1	12.0(5)T	Performs basic TED functionality on nonredundant networks.
TEDv2	12.1M	Enhanced to work with redundant networks with paths through multiple security gateways between the source and the destination.
TEDv3	12.2M	Enhanced to allow non-IP-related entries to be used in the access list.

TED Restrictions

Tunnel Endpoint Discovery has the following restrictions:

- It is Cisco proprietary.
- It is available only on dynamic crypto maps. (The dynamic crypto map template is based on the dynamic crypto map performing peer discovery. Although there are no access-list restrictions on the dynamic crypto map template, the dynamic crypto map template should cover data sourced from the protected traffic and the receiving router using the **any** keyword. When using the **any** keyword, include explicit **deny** statements to exempt routing protocol traffic prior to entering the **permit any** command.)
- TED works only in tunnel mode; that is, it does not work in transport mode.
- It is limited by the performance and scalability of limitation of IPSec on each individual platform.



Note Enabling TED slightly decreases the general scalability of IPSec because of the set-up overhead of peer discovery, which involves an additional “round-trip” of IKE messages (TED probe and reply). Although minimal, the additional memory used to store data structures during the peer discovery stage adversely affects the general scalability of IPSec.

- The IP addresses must be able to be routed within the network.
- The access list used in the crypto map for TED can only contain IP-related entries—TCP, UDP, or any other protocol cannot be used in the access list.



Note This restriction is no longer applicable in TEDv3.

To create a dynamic crypto map entry with Tunnel Endpoint Discovery (TED) configured, use the following commands, beginning in crypto-map configuration mode:

Command	Purpose
Step 1 Router(config)# crypto dynamic-map <i>dynamic-map-name</i> <i>dynamic-map-number</i> Router (config-crypto-m)# set transform-set <i>transform-set-name1</i> [<i>transform-set-name2</i> ... <i>transform-set-name6</i>] Router (config-crypto-m)# match address <i>access-list-id</i> Router (config-crypto-m)# set security-association lifetime seconds <i>seconds</i> and/or Router (config-crypto-m)# set security-association lifetime kilobytes <i>kilobytes</i> Router (config-crypto-m)# set pfs [<i>group1</i> <i>group2</i>] Router (config-crypto-m)# exit	Configures a dynamic crypto map using the crypto dynamic-map command. Note You <i>must</i> configure a match address ; otherwise, the behavior is not secure, and you cannot enable TED because packets are sent in the clear (unencrypted.)
Step 2 Router(config)# crypto map <i>map-name</i> <i>map-number</i> ipsec-isakmp dynamic <i>dynamic-map-name</i> [discover]	Adds a dynamic crypto map to a crypto map set. Enter the discover keyword on the dynamic crypto map to enable TED.

Clearing IKE Connections

To clear IKE connections, use the following commands in EXEC mode:

	Command	Purpose
Step 1	Router# show crypto isakmp sa	Displays existing IKE connections; note the connection identifiers for connections you want to clear.
Step 2	Router# clear crypto isakmp [<i>connection-id</i>]	Clears IKE connections.

Troubleshooting IKE

To assist in troubleshooting IKE, use the following commands in EXEC mode:

Command	Purpose
Router# show crypto isakmp policy	Displays the parameters for each configured IKE policy.
Router# show crypto isakmp sa	Displays all current IKE security associations.
Router# show crypto map	Displays the crypto map configuration.
Router# show running-config	Verifies IKE configuration.
Router# debug crypto isakmp	Displays debug messages about IKE events.

What To Do Next

After IKE configuration is complete, you can configure IPSec. IPSec configuration is described in the chapter “Configuring IPSec Network Security.”

IKE Configuration Examples

The following sections provide IKE configuration examples:

- [Creating IKE Policies Examples](#)
- [Configuring Preshared Keys Using a AAA Server Example](#)
- [Configuring IKE Extended Authentication \(Xauth\) Examples](#)

Creating IKE Policies Examples

This example creates two IKE policies, with policy 15 as the highest priority, policy 20 as the next priority, and the existing default priority as the lowest priority. It also creates a preshared key to be used with policy 20 with the remote peer whose IP address is 192.168.224.33.

```
crypto isakmp policy 15
  encryption 3des
  hash md5
  authentication rsa-sig
  group 2
  lifetime 5000
crypto isakmp policy 20
  authentication pre-share
  lifetime 10000
crypto isakmp key 1234567890 address 192.168.224.33
```

In the example, the **encryption des** of policy 15 would not appear in the written configuration because this is the default value for the encryption algorithm parameter.

If the **show crypto isakmp policy** command is issued with this configuration, the output is as follows:

```
Protection suite priority 15
encryption algorithm:3DES - Triple Data Encryption Standard (168 bit keys)
hash algorithm:Message Digest 5
authentication method:Rivest-Shamir-Adleman Signature
Diffie-Hellman group:#2 (1024 bit)
lifetime:5000 seconds, no volume limit
Protection suite priority 20
encryption algorithm:DES - Data Encryption Standard (56 bit keys)
hash algorithm:Secure Hash Standard
authentication method:preshared Key
Diffie-Hellman group:#1 (768 bit)
lifetime:10000 seconds, no volume limit
Default protection suite
encryption algorithm:DES - Data Encryption Standard (56 bit keys)
hash algorithm:Secure Hash Standard
authentication method:Rivest-Shamir-Adleman Signature
Diffie-Hellman group:#1 (768 bit)
lifetime:86400 seconds, no volume limit
```

Note that although the output shows “no volume limit” for the lifetimes, you can configure only a time lifetime (such as 86,400 seconds); volume-limit lifetimes are not configurable.

Configuring Preshared Keys Using a AAA Server Example

The following example shows how to configure a dynamic crypto map that will query a AAA server for a preshared key:

```
aaa new-model
aaa authorization network mylist group radius

!This defines the AAA server used for authorization.

crypto dynamic-map foo 10
  set security-association lifetime seconds 120
  set transform-set proposal1 proposal2
!
crypto map foo isakmp authorization list mylist
crypto map foo 10 ipsec-isakmp dynamic foo

! This sets up a dynamic crypto-map, which will query AAA for a shared secret.
```

Configuring IKE Extended Authentication (Xauth) Examples

The following sections provide examples of Xauth configurations with crypto maps:

- [Configuring Xauth with Static Crypto Map Example](#)
- [Configuring Xauth with Dynamic Crypto Map Example](#)

Configuring Xauth with Static Crypto Map Example

In the following example output from the **show running configuration** global configuration command, Xauth is configured with preshared key using AAA local policy:

```
aaa new-model
aaa authentication login xauthlist local
!
username robin password cisco1234
!
crypto ipsec transform-set xauthtransform esp-des esp-md5-hmac
!
crypto isakmp policy 1
 hash md5
 authentication pre-share
crypto isakmp key cisco1234 address 209.165.202.145
!
crypto map xauthmap client authentication list xauthlist
crypto map xauthmap 10 ipsec-isakmp
 set peer 209.165.202.145
 set transform-set xauthtransform
 match address 192
!
interface Ethernet1/0
 ip address 209.165.202.147 255.255.255.224
 crypto map xauthmap
!
access-list 192 permit ip host 209.165.202.147 host 209.165.202.145
```

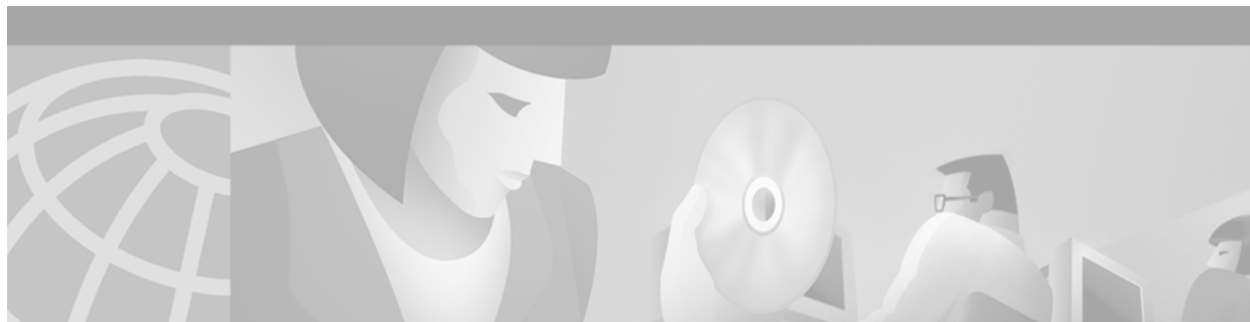
Configuring Xauth with Dynamic Crypto Map Example

In the following example output from the **show running configuration** global configuration command, a corporate gateway uses Xauth configured on a RADIUS authentication server. Digital certification is also configured with dynamic crypto maps for scalability. This allows for both remote user authentication and device authentication.

```
aaa new-model
radius-server host alcatraz
radius-server key cisco12345
aaa authentication login xauthlist radius
!
crypto ipsec transform-set remote esp-des esp-md5-hmac
!
crypto ca identity myca
 enrollment url http://myca.cisco.com:80
crypto ca certificate chain myca
 certificate ca <cert-serial-number>
 <hex data>
 certificate
 <hex data>
!
```



```
crypto dynamic-map xauthdynamic 10
  set transform-set xauthtransform
!
crypto map xauthmap client authentication list xauthlist
crypto map xauthmap 10 ipsec-isakmp dynamic xauthdynamic
!
interface Ethernet1/0
  ip address 209.165.202.147 255.255.255.224
  crypto map xauthmap
```

Configuring Passwords and Privileges

Using passwords and assigning privilege levels is a simple way of providing terminal access control in your network.

For a complete description of the commands used in this chapter, refer to the “Password and Privileges Commands” chapter in the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the “Identifying Supported Platforms” section in the chapter “Using Cisco IOS Software.”

In This Chapter

This chapter includes the following sections:

- [Protecting Access to Privileged EXEC Commands](#)
- [Configuring Multiple Privilege Levels](#)
- [Recovering a Lost Enable Password](#)
- [Recovering a Lost Line Password](#)
- [Configuring Identification Support](#)
- [Passwords and Privileges Configuration Examples](#)

Protecting Access to Privileged EXEC Commands

The following tasks provide a way to control access to the system configuration file and privileged EXEC (enable) commands:

- [Setting or Changing a Static Enable Password](#)
- [Protecting Passwords with Enable Password and Enable Secret](#)
- [Setting or Changing a Line Password](#)
- [Encrypting Passwords](#)

Setting or Changing a Static Enable Password

To set or change a static password that controls access to privileged EXEC (enable) mode, use the following command in global configuration mode:

Command	Purpose
Router(config)# enable password <i>password</i>	Establishes a new password or change an existing password for the privileged command level.

For examples of how to define enable passwords for different privilege levels, see the section [“Multiple Levels of Privileges Examples”](#) at the end of this chapter.

Protecting Passwords with Enable Password and Enable Secret

To provide an additional layer of security, particularly for passwords that cross the network or are stored on a TFTP server, you can use either the **enable password** or **enable secret** commands. Both commands accomplish the same thing; that is, they allow you to establish an encrypted password that users must enter to access enable mode (the default), or any privilege level you specify.

We recommend that you use the **enable secret** command because it uses an improved encryption algorithm. Use the **enable password** command only if you boot an older image of the Cisco IOS software, or if you boot older boot ROMs that do not recognize the **enable secret** command.

If you configure the **enable secret** command, it takes precedence over the **enable password** command; the two commands cannot be in effect simultaneously.



Caution

If neither the **enable password** command nor the **enable secret** command is configured, and if there is a line password configured for the console, the console line password will serve as the enable password for all VTY (Telnet and Secure Shell [SSH]) sessions.

To configure the router to require an enable password, use either of the following commands in global configuration mode:

Command	Purpose
Router(config)# enable password [level <i>level</i>] { <i>password</i> <i>encryption-type</i> <i>encrypted-password</i> }	Establishes a password for a privilege command mode.
or	
Router(config)# enable secret [level <i>level</i>] { <i>password</i> <i>encryption-type</i> <i>encrypted-password</i> }	Specifies a secret password, saved using a non-reversible encryption method. (If enable password and enable secret are both set, users must enter the enable secret password.)

Use either of these commands with the **level** option to define a password for a specific privilege level. After you specify the level and set a password, give the password only to users who need to have access at this level. Use the **privilege level** configuration command to specify commands accessible at various levels.

If you have the **service password-encryption** command enabled, the password you enter is encrypted. When you display it with the **more system:running-config** command, it is displayed in encrypted form.

If you specify an encryption type, you must provide an encrypted password—an encrypted password you copy from another router configuration.

**Note**

You cannot recover a lost encrypted password. You must clear NVRAM and set a new password. See the section “[Recovering a Lost Enable Password](#)” or “[Recovering a Lost Line Password](#)” in this chapter if you have lost or forgotten your password.

Setting or Changing a Line Password

To set or change a password on a line, use the following command in global configuration mode:

Command	Purpose
Router(config)# password <i>password</i>	Establishes a new password or change an existing password for the privileged command level.

Encrypting Passwords

Because protocol analyzers can examine packets (and read passwords), you can increase access security by configuring the Cisco IOS software to encrypt passwords. Encryption prevents the password from being readable in the configuration file.

To configure the Cisco IOS software to encrypt passwords, use the following command in global configuration mode:

Command	Purpose
Router(config)# service password-encryption	Encrypts a password.

The actual encryption process occurs when the current configuration is written or when a password is configured. Password encryption is applied to all passwords, including authentication key passwords, the privileged command password, console and virtual terminal line access passwords, and BGP neighbor passwords. The **service password-encryption** command is primarily useful for keeping unauthorized individuals from viewing your password in your configuration file.

**Caution**

The **service password-encryption** command does not provide a high level of network security. If you use this command, you should also take additional network security measures.

Although you cannot recover a lost encrypted password (that is, you cannot get the original password back), you can recover from a lost encrypted password. See the section “[Recovering a Lost Enable Password](#)” or “[Recovering a Lost Line Password](#)” in this chapter if you have lost or forgotten your password.

Configuring Multiple Privilege Levels

By default, the Cisco IOS software command-line interface (CLI) has two levels of access to commands: user EXEC mode (level 1) and privileged EXEC mode (level 15). However, you can configure additional levels of access to commands, called privilege levels, to meet the needs of your users while protecting the system from unauthorized access. Up to 16 privilege levels can be configured, from level 0, which is the most restricted level, to level 15, which is the least restricted level.

Access to each privilege level is enabled through separate passwords, which you specify when configuring the privilege level.

For example, if you want a certain set of users to be able to configure only certain interfaces, but not allow them access to other configuration options, you could create a separate privilege level for only specific interface configuration commands and distribute the password for that level to those users.

In addition to configuring the privilege levels locally on the Cisco networking device, these command privileges can also be implemented using AAA with TACACS+ and RADIUS. For example, TACACS+ provides two ways to control the authorization of router commands on a per-user or per-group basis. The first way is to assign privilege levels to commands and have the router verify with the TACACS+ server whether or not the user is authorized at the specified privilege level. The second way is to explicitly specify in the TACACS+ server, on a per-user or per-group basis, the commands that are allowed. For more information about implementing AAA with TACACS+ and RADIUS, see the technical note [How to Assign Privilege Levels with TACACS+ and RADIUS](#).

The following tasks describe how to configure additional levels of security:

- [Setting the Privilege Level for a Command](#)
- [Changing the Default Privilege Level for Lines](#)
- [Displaying Current Privilege Levels](#)
- [Logging In to a Privilege Level](#)

Setting the Privilege Level for a Command

To create a new privilege level and associate commands with that privilege level, use the following commands in beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# privilege mode level level command-string	Configures the specified privilege level to allow access to the specified command.
Step 2	Router(config)# enable secret level level {0 5} password-string	Sets the password for the specified privilege level. This is the password users will enter after entering the enable level command to access the specified level. <ul style="list-style-type: none"> • 0 indicates an unencrypted password string follows; 5 indicates an encrypted password string follows.

	Command	Purpose
Step 3	Router(config)# exit	Exists global configuration mode and returns to EXEC mode.
Step 4	Router# do copy running-config startup-config	(Optional) Saves the configuration to the startup configuration file in NVRAM. Note The do keyword allows execution of EXEC commands in configuration mode.

Changing the Default Privilege Level for Lines

To change the default privilege level for a given line or a group of lines, use the following command in line configuration mode:

Command	Purpose
Router(config-line)# privilege level level	Specifies a default privilege level for a line.

Displaying Current Privilege Levels

To display the current privilege level you can access based on the password you used, use the following command in EXEC mode:

Command	Purpose
Router# show privilege	Displays your current privilege level.

Logging In to a Privilege Level

To log into a router at a specified privilege level, use the following command in EXEC mode:

Command	Purpose
Router# enable level	Logs in to a specified privilege level.

To exit to a specified privilege level, use the following command in EXEC mode:

Command	Purpose
Router# disable level	Exits to a specified privilege level.

Recovering a Lost Enable Password

You can restore access to enable mode on a router when the password is lost using one of the three procedures described in this section. The procedure you use depends on your router platform.

You can perform password recovery on most of the platforms without changing hardware jumpers, but all platforms require the configuration to be reloaded. Password recovery can be done only from the console port on the router. [Table 27](#) shows which password recovery procedure to use with each router platform.

Table 27 Platform-Specific Password Recovery Procedures

Password Recovery Procedure	Router Platform
Password Recovery Procedure 1	Cisco 2000 series
	Cisco 2500 series
	Cisco 3000 series
	Cisco 4000 series with 680x0 Motorola CPU
	Cisco 7000 series running Cisco IOS Release 10.0 or later in ROMs installed on the RP card
	IGS series running Cisco IOS Release 9.1 or later in ROMs
Password Recovery Procedure 2	Cisco 1003
	Cisco 1600 series
	Cisco 2600 series
	Cisco 3600 series
	Cisco 4500 series
	Cisco 7100 series
	Cisco 7200 series
	Cisco 7500 series
	IDT Orion-based routers
	Cisco AS5200 and AS5300 platforms

This section includes the following sections:

- [Password Recovery Process](#)
- [Password Recovery Procedure 1](#)
- [Password Recovery Procedure 2](#)

Password Recovery Process

Both password recovery procedures involve the following basic steps:

-
- | | |
|---------------|--|
| Step 1 | Configure the router to boot up without reading the configuration memory (NVRAM). This is sometimes called the test system mode. |
| Step 2 | Reboot the system. |
| Step 3 | Access enable mode (which can be done without a password if you are in test system mode). |
| Step 4 | View or change the password, or erase the configuration. |
| Step 5 | Reconfigure the router to boot up and read the NVRAM as it normally does. |

Step 6 Reboot the system.

**Note**

Some password recovery requires that a terminal issue a Break signal; you must be familiar with how your terminal or PC terminal emulator issues this signal. For example, in ProComm, the keys Alt-B by default generates the Break signal, and in a Windows terminal you press Break or CTRL-Break. A Windows terminal also allows you to define a function key as a BREAK signal. To do so, select function keys from the Terminal window and define one as Break by entering the characters ^\$B (**Shift 6**, **Shift 4**, and uppercase **B**).

Password Recovery Procedure 1

Use this procedure to recover lost passwords on the following Cisco routers:

- Cisco 2000 series
- Cisco 2500 series
- Cisco 3000 series
- Cisco 4000 series with 680x0 Motorola CPU
- Cisco 7000 series running Cisco IOS Release 10.0 or later in ROMs installed on the RP card. The router can be booting Cisco IOS Release 10.0 software in Flash memory, but it needs the actual ROMs on the processor card too.
- IGS series running Cisco IOS Release 9.1 or later in ROMs

To recover a password using Procedure 1, perform the following steps:

Step 1 Attach a terminal or PC with terminal emulation software to the console port of the router.

Step 2 Enter the **show version** command and record the setting of the configuration register. It is usually 0x2102 or 0x102.

The configuration register value is on the last line of the display. Note whether the configuration register is set to enable Break or disable Break.

The factory-default configuration register value is 0x2102. Notice that the third digit from the left in this value is 1, which disables Break. If the third digit is *not* 1, Break is enabled.

Step 3 Turn off the router, then turn it on.

Step 4 Press the **Break** key on the terminal within 60 seconds of turning on the router.

The `rommon>` prompt with no router name appears. If it does not appear, the terminal is not sending the correct Break signal. In that case, check the terminal or terminal emulation setup.

Step 5 Enter **o/r0x42** at the `rommon>` prompt to boot from Flash memory or **o/r0x41** to boot from the boot ROMs.

**Note**

The first character is the letter o, not the numeral zero. If you have Flash memory and it is intact, 0x42 is the best setting. Use 0x41 only if the Flash memory is erased or not installed. If you use 0x41, you can only view or erase the configuration. You cannot change the password.

Step 6 At the `rommon>` prompt, enter the `initialize` command to initialize the router.

This causes the router to reboot but ignore its saved configuration and use the image in Flash memory instead. The system configuration display appears.



Note If you normally use the **boot network** command, or if you have multiple images in Flash memory and you boot a non-default image, the image in Flash might be different.

Step 7 Enter **no** in response to the System Configuration Dialog prompts until the following message appears:
Press RETURN to get started!

Step 8 Press **Return**.

The `Router>` prompt appears.

Step 9 Enter **enable**.

The `Router#` prompt appears.

Step 10 Choose one of the following options:

- To view the password, if it is not encrypted, enter **more nvram:startup-config**.
- To change the password (if it is encrypted, for example), enter the following commands:

```
Router# configure memory
Router# configure terminal
Router(config)# enable secret 1234abcd
Router(config)# ctrl-z
Router# write memory
```



Note The **enable secret** command provides increased security by storing the enable secret password using a non-reversible cryptographic function; however, you cannot recover a lost password that has been encrypted.

Step 11 Enter **configure terminal** at the EXEC prompt to enter configuration mode.

Step 12 Enter **config-register** and whatever value you recorded in Step 2.

Step 13 Press **Ctrl-Z** to quit from the configuration editor.

Step 14 Enter **reload** at the privileged EXEC prompt and enter **write memory** to save the configuration.

Password Recovery Procedure 2


Use this procedure to recover lost passwords on the following routers:

- Cisco 1003
- Cisco 1600 series
- Cisco 2600 series
- Cisco 3600 series
- Cisco 3810
- Cisco 4500 series

- Cisco 7100 series
- Cisco 7200 series
- Cisco 7500 series
- IDT Orion-Based Routers
- Cisco AS5200 and AS5300 platforms

To recover a password using Procedure 2, perform the following steps:

-
- Step 1** Attach a terminal or PC with terminal emulation software to the console port of the router.
- Step 2** Enter **show version** and record the setting of the configuration register. It is usually 0x2102 or 0x102. The configuration register value is on the last line of the display. Note whether the configuration register is set to enable Break or disable Break.
- The factory-default configuration register value is 0x2102. Notice that the third digit from the left in this value is 1, which disables Break. If the third digit is *not* 1, Break is enabled.
- Step 3** Turn off the router, then turn it on.
- Step 4** Press the **Break** key on the terminal within 60 seconds of turning on the router.
- The `rommon>` prompt appears. If it does not appear, the terminal is not sending the correct Break signal. In that case, check the terminal or terminal emulation setup.
- Step 5** Enter **confreg** at the `rommon>` prompt.
- The following prompt appears:
- ```
Do you wish to change configuration [y/n]?
```
- Step 6** Enter **yes** and press **Return**.
- Step 7** Enter **no** to subsequent questions until the following prompt appears:
- ```
ignore system config info [y/n]?
```
- Step 8** Enter **yes**.
- Step 9** Enter **no** to subsequent questions until the following prompt appears:
- ```
change boot characteristics [y/n]?
```
- Step 10** Enter **yes**.
- The following prompt appears:
- ```
enter to boot:
```
- Step 11** At this prompt, either enter **2** and press **Return** if Flash memory or, if Flash memory is erased, enter **1**. If Flash memory is erased, the Cisco 4500 must be returned to Cisco for service. If you enter **1**, you can only view or erase the configuration. You cannot change the password.
- A configuration summary is displayed and the following prompt appears:
- ```
Do you wish to change configuration [y/n]?
```
- Step 12** Enter **no** and press **Return**.
- The following prompt appears:
- ```
rommon>
```

- Step 13** Enter **reset** at the rommon prompt or, for Cisco 4500 series and Cisco 7500 series routers, power cycle the router.
- Step 14** As the router boots, enter **no** to all the setup questions until the following prompt appears:
- ```
Router>
```
- Step 15** Enter **enable** to enter enable mode.
- The `Router#` prompt appears.
- Step 16** Choose one of the following options:
- To view the password, if it is not encrypted, enter **more nvram:startup-config**.
  - To change the password (if it is encrypted, for example), enter the following commands:
- ```
Router# configure memory
Router# configure terminal
Router(config)# enable secret 1234abcd
Router(config)# ctrl-z
Router# write memory
```
-
-  **Note** The **enable secret** command provides increased security by storing the enable secret password using a non-reversible cryptographic function; however, you cannot recover a lost password that has been encrypted.
-
- Step 17** Enter **configure terminal** at the prompt.
- Step 18** Enter **config-register** and whatever value you recorded in Step 2.
- Step 19** Press **Ctrl-Z** to quit from the configuration editor.
- Step 20** Enter **reload** at the prompt and enter **write memory** to save the configuration.
-

Recovering a Lost Line Password

If your router has the nonvolatile memory option, you can accidentally lock yourself out of enable mode if you enable password checking on the console terminal line and then forget the line password. To recover a lost line password, perform the following steps:

-
- Step 1** Force the router into factory diagnostic mode.
- See the hardware installation and maintenance publication for your product for specific information about setting the processor configuration register to factory diagnostic mode. [Table 28](#) summarizes the hardware or software settings required by various products to set factory diagnostic mode.
- Step 2** Enter **Yes** when asked if you want to set the manufacturers' addresses.
- The following prompt appears:
- ```
TEST-SYSTEM >
```
- Step 3** Enter **enable** to enter enable mode:
- ```
TEST-SYSTEM > enable
```

- Step 4** Enter **more nvram:startup-config** to review the system configuration and find the password. Do not change anything in the factory diagnostic mode.
- ```
TEST-SYSTEM # more nvram:startup-config
```
- Step 5** To resume normal operation, restart the router or reset the configuration register.
- Step 6** Log in to the router with the password that was shown in the configuration file.

**Note**

All debugging capabilities are turned on during diagnostic mode.

See the hardware installation and maintenance publication for your product for specific information about configuring the processor configuration register for factory diagnostic mode. [Table 28](#) summarizes the hardware or software settings required by the various products to set factory diagnostic mode.

**Table 28** *Factory Diagnostic Mode Settings for the Configuration Register*

| Platform          | Setting                                                                                                                                                                                                                                           |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Modular products  | Set jumper in bit 15 of the processor configuration register, then restart; remove the jumper when finished.                                                                                                                                      |
| Cisco AS5100      | Use the <b>config-register</b> command to set the processor configuration register to 0x8000, then initialize and boot the system. Use the <b>reload</b> command to restart and set the processor configuration register to 0x2102 when finished. |
| Cisco AS5200      |                                                                                                                                                                                                                                                   |
| Cisco AS5300      |                                                                                                                                                                                                                                                   |
| Cisco 1600 series |                                                                                                                                                                                                                                                   |
| Cisco 2500 series |                                                                                                                                                                                                                                                   |
| Cisco 3000 series |                                                                                                                                                                                                                                                   |
| Cisco 3600 series |                                                                                                                                                                                                                                                   |
| Cisco 4000 series |                                                                                                                                                                                                                                                   |
| Cisco 4500 series |                                                                                                                                                                                                                                                   |
| Cisco 7000 series |                                                                                                                                                                                                                                                   |
| Cisco 7100 series |                                                                                                                                                                                                                                                   |
| Cisco 7200 series |                                                                                                                                                                                                                                                   |
| Cisco 7500 series |                                                                                                                                                                                                                                                   |

## Configuring Identification Support

Identification support allows you to query a Transmission Control Protocol (TCP) port for identification. This feature enables an unsecure protocol, described in RFC 1413, to report the identity of a client initiating a TCP connection and a host responding to the connection. With identification support, you can connect a TCP port on a host, issue a simple text string to request information, and receive a simple text-string reply.

To configure identification support, use the following command in global configuration mode:

| Command                          | Purpose                         |
|----------------------------------|---------------------------------|
| Router(config)# <b>ip identd</b> | Enables identification support. |

## Passwords and Privileges Configuration Examples

The following sections provide password and privileges configuration examples:

- [Multiple Levels of Privileges Examples](#)
- [Username Examples](#)

### Multiple Levels of Privileges Examples

This section provides examples of using multiple privilege levels to specify who can access different sets of commands. This section includes the following sections:

- [Allowing Users to Clear Lines Examples](#)
- [Defining an Enable Password for System Operators Examples](#)
- [Disabling a Privilege Level Example](#)

#### Allowing Users to Clear Lines Examples

If you want to allow users to clear lines, you can do either of the following:

- Change the privilege level for the **clear** and **clear line** commands to 1 or “ordinary user level,” as follows. This allows any user to clear lines.

```
privilege exec level 1 clear line
```

- Change the privilege level for the **clear** and **clear line** commands to level 2. To do so, use the **privilege level** global configuration command to specify privilege level 2. Then define an enable password for privilege level 2 and tell only those users who need to know what the password is.

```
enable password level 2 pswd2
privilege exec level 2 clear line
```

#### Defining an Enable Password for System Operators Examples

In the following example, you define an enable password for privilege level 10 for system operators and make **clear** and **debug** commands available to anyone with that privilege level enabled.

```
enable password level 10 pswd10
privilege exec level 10 clear line
privilege exec level 10 debug ppp chap
privilege exec level 10 debug ppp error
privilege exec level 10 debug ppp negotiation
```

The following example lowers the privilege level of the **more system:running-config** command and most configuration commands to operator level so that the configuration can be viewed by an operator. It leaves the privilege level of the **configure** command at 15. Individual configuration commands are

displayed in the **more system:running-config** output only if the privilege level for a command has been lowered to 10. Users are allowed to see only those commands that have a privilege level less than or equal to their current privilege level.

```
enable password level 15 pswd15
privilege exec level 15 configure
enable password level 10 pswd10
privilege exec level 10 more system:running-config
```

## Disabling a Privilege Level Example

In the following example, the **show ip route** command is set to privilege level 15. To keep all **show ip** and **show** commands from also being set to privilege level 15, these commands are specified to be privilege level 1.

```
privilege exec level 15 show ip route
privilege exec level 1 show ip
privilege exec level 1 show
```

## Username Examples

The following sample configuration sets up secret passwords on Routers A, B, and C, to enable the three routers to connect to each other.

To authenticate connections between Routers A and B, enter the following commands:

On Router A:

```
username B password a-b_secret
```

On Router B:

```
username A password a-b_secret
```

To authenticate connections between Routers A and C, enter the following commands:

On Router A:

```
username C password a-c_secret
```

On Router C:

```
username A password a-c_secret
```

To authenticate connections between Routers B and C, enter the following commands:

On Router B:

```
username C password b-c_secret
```

On Router C:

```
username B password b-c_secret
```

For example, suppose you enter the following command:

```
username bill password westward
```

The system displays this command as follows:

```
username bill password 7 21398211
```

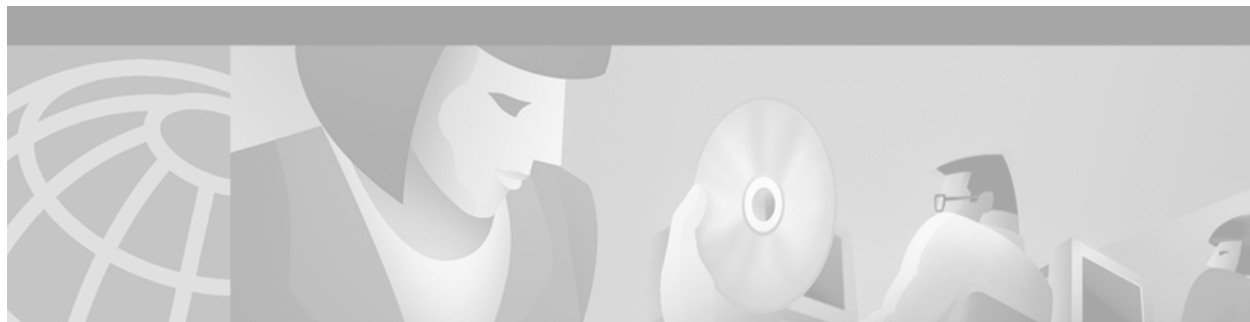
The encrypted version of the password is 21398211. The password was encrypted by the Cisco-defined encryption algorithm, as indicated by the “7.”

However, if you enter the following command, the system determines that the password is already encrypted and performs no encryption. Instead, it displays the command exactly as you entered it.

```
username bill password 7 21398211
```

```
username bill password 7 21398211
```





# Neighbor Router Authentication: Overview and Guidelines

---

You can prevent your router from receiving fraudulent route updates by configuring neighbor router authentication.

This chapter describes neighbor router authentication as part of a total security plan. It describes what neighbor router authentication is, how it works, and why you should use it to increase your overall network security.

This chapter refers to neighbor router authentication as “neighbor authentication.” Neighbor router authentication is also sometimes called “route authentication.”

## In This Chapter

This chapter describes the following topics:

- [About Neighbor Authentication](#)
- [How Neighbor Authentication Works](#)
- [Key Management \(Key Chains\)](#)
- [Finding Neighbor Authentication Configuration Information](#)

## About Neighbor Authentication

This section contains the following sections:

- [Benefits of Neighbor Authentication](#)
- [Protocols That Use Neighbor Authentication](#)
- [When to Configure Neighbor Authentication](#)

## Benefits of Neighbor Authentication

When configured, neighbor authentication occurs whenever routing updates are exchanged between neighbor routers. This authentication ensures that a router receives reliable routing information from a trusted source.

Without neighbor authentication, unauthorized or deliberately malicious routing updates could compromise the security of your network traffic. A security compromise could occur if an unfriendly party diverts or analyzes your network traffic. For example, an unauthorized router could send a fictitious routing update to convince your router to send traffic to an incorrect destination. This diverted traffic could be analyzed to learn confidential information of your organization, or merely used to disrupt your organization's ability to effectively communicate using the network.

Neighbor authentication prevents any such fraudulent route updates from being received by your router.

## Protocols That Use Neighbor Authentication

Neighbor authentication can be configured for the following routing protocols:

- Border Gateway Protocol (BGP)
- DRP Server Agent
- Intermediate System-to-Intermediate System (IS-IS)
- IP Enhanced Interior Gateway Routing Protocol (EIGRP)
- Open Shortest Path First (OSPF)
- Routing Information Protocol (RIP) version 2

## When to Configure Neighbor Authentication

You should configure any router for neighbor authentication if that router meets all of these conditions:

- The router uses any of the routing protocols previously mentioned.
- It is conceivable that the router might receive a false route update.
- If the router were to receive a false route update, your network might be compromised.
- If you configure a router for neighbor authentication, you also need to configure the neighbor router for neighbor authentication.

## How Neighbor Authentication Works

When neighbor authentication has been configured on a router, the router authenticates the source of each routing update packet that it receives. This is accomplished by the exchange of an authenticating key (sometimes referred to as a password) that is known to both the sending and the receiving router.

There are two types of neighbor authentication used: plain text authentication and Message Digest Algorithm Version 5 (MD5) authentication. Both forms work in the same way, with the exception that MD5 sends a "message digest" instead of the authenticating key itself. The message digest is created using the key and a message, but the key itself is not sent, preventing it from being read while it is being transmitted. Plain text authentication sends the authenticating key itself over the wire.



### Note

Note that plain text authentication is not recommended for use as part of your security strategy. Its primary use is to avoid accidental changes to the routing infrastructure. Using MD5 authentication, however, is a recommended security practice.

**Caution**

As with all keys, passwords, and other security secrets, it is imperative that you closely guard authenticating keys used in neighbor authentication. The security benefits of this feature are reliant upon your keeping all authenticating keys confidential. Also, when performing router management tasks via Simple Network Management Protocol (SNMP), do not ignore the risk associated with sending keys using non-encrypted SNMP.

This section includes the following sections:

- [Plain Text Authentication](#)
- [MD5 Authentication](#)

## Plain Text Authentication

Each participating neighbor router must share an authenticating key. This key is specified at each router during configuration. Multiple keys can be specified with some protocols; each key must then be identified by a key number.

In general, when a routing update is sent, the following authentication sequence occurs:

- 
- Step 1** A router sends a routing update with a key and the corresponding key number to the neighbor router. In protocols that can have only one key, the key number is always zero.
  - Step 2** The receiving (neighbor) router checks the received key against the same key stored in its own memory.
  - Step 3** If the two keys match, the receiving router accepts the routing update packet. If the two keys do not match, the routing update packet is rejected.

These protocols use plain text authentication:

- DRP Server Agent
  - IS-IS
  - OSPF
  - RIP version 2
- 

## MD5 Authentication

MD5 authentication works similarly to plain text authentication, except that the key is never sent over the wire. Instead, the router uses the MD5 algorithm to produce a “message digest” of the key (also called a “hash”). The message digest is then sent instead of the key itself. This ensures that nobody can eavesdrop on the line and learn keys during transmission.

These protocols use MD5 authentication:

- OSPF
- RIP version 2
- BGP
- IP Enhanced IGRP

# Key Management (Key Chains)

You can configure key chains for these IP routing protocols:

- RIP version 2
- IP Enhanced IGRP
- DRP Server Agent

These routing protocols offer the additional function of managing keys by using key chains. When you configure a key chain, you specify a series of keys with lifetimes, and the Cisco IOS software rotates through each of these keys. This decreases the likelihood that keys will be compromised.

Each key definition within the key chain must specify a time interval for which that key will be activated (its “lifetime”). Then, during a given key’s lifetime, routing update packets are sent with this activated key. Keys cannot be used during time periods for which they are not activated. Therefore, it is recommended that for a given key chain, key activation times overlap to avoid any period of time for which no key is activated. If a time period occurs during which no key is activated, neighbor authentication cannot occur, and therefore routing updates will fail.

Multiple key chains can be specified.

Note that the router needs to know the time to be able to rotate through keys in synchronization with the other participating routers, so that all routers are using the same key at the same moment. Refer to the Network Time Protocol (NTP) and calendar commands in the “Performing Basic System Management” chapter of the *Cisco IOS Configuration Fundamentals Configuration Guide* for information about configuring time at your router.

# Finding Neighbor Authentication Configuration Information

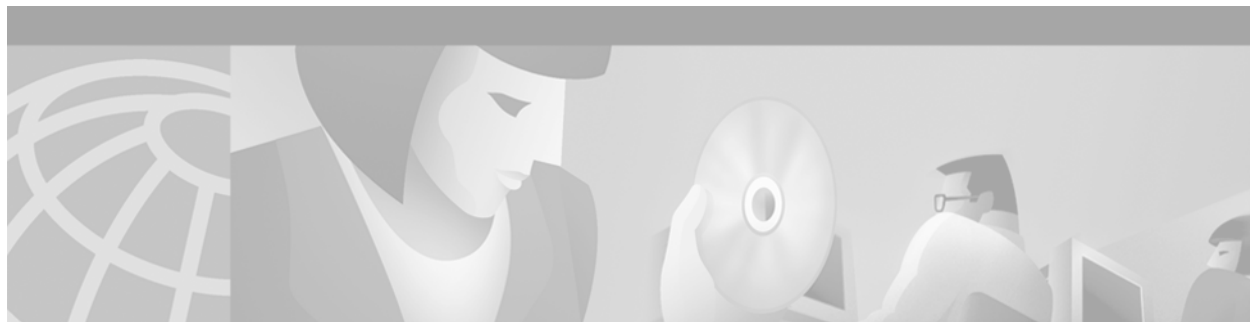
To find complete configuration information for neighbor authentication, refer to the appropriate section and chapter in the *Cisco IOS IP Configuration Guide* as listed in [Table 29](#).

**Table 29** Location of Neighbor Authentication Information for Each Supported Protocol

| Protocol         | Chapter                        | Section                                                                                                           |
|------------------|--------------------------------|-------------------------------------------------------------------------------------------------------------------|
| BGP              | “Configuring BGP”              | “Configuring Neighbor Options”                                                                                    |
| DRP Server Agent | “Configuring IP Services”      | “Configuring a DRP Server Agent”                                                                                  |
| IP Enhanced IGRP | “Configuring IP Enhanced IGRP” | “Configuring Enhanced IGRP Route Authentication”                                                                  |
| IS-IS            | “Configuring Integrated IS-IS” | “Assigning a Password for an Interface” and<br>“Configuring IS-IS Authentication Passwords”                       |
| OSPF             | “Configuring OSPF”             | “Configuring OSPF Interface Parameters” and<br>“Configuring OSPF Area Parameters” and<br>“Creating Virtual Links” |
| RIP version 2    | “Configuring RIP”              | “Enabling RIP Authentication”                                                                                     |

To find complete configuration information for key chains, refer to the “Managing Authentication Keys” section in the chapter “Configuring IP Routing Protocol-Independent Features” of the *Cisco IOS IP Configuration Guide*.





## Configuring IP Security Options

---

Cisco provides IP Security Option (IPSO) support as described in RFC 1108. Cisco's implementation is only minimally compliant with RFC 1108 because the Cisco IOS software only accepts and generates a 4-byte IPSO.

IPSO is generally used to comply with the U.S. government's Department of Defense security policy.

For a complete description of IPSO commands, refer to the chapter "IP Security Options Commands" of the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the "Identifying Supported Platforms" section in the chapter "Using Cisco IOS Software."

## In This Chapter

This chapter describes how to configure IPSO for both the basic and extended security options described in RFC 1108. This chapter also describes how to configure auditing for IPSO. This chapter includes the following sections:

- [IPSO Configuration Task List](#)
- [IPSO Configuration Examples](#)

## IPSO Configuration Task List

This section describes the following configuration tasks:

- [Configuring Basic IP Security Options](#)
- [Configuring Extended IP Security Options](#)
- [Configuring the DNSIX Audit Trail Facility](#)

## Configuring Basic IP Security Options

Cisco's basic IPSO support provides the following features:

- Defines security level on a per-interface basis
- Defines single-level or multilevel interfaces
- Provides a label for incoming packets
- Strips labels on a per-interface basis
- Reorders options to put any basic security options first

To configure basic IPSO, complete the tasks in the following sections:

- [Enabling IPSO and Setting the Security Classifications](#)
- [Specifying How IP Security Options Are Processed](#)

### Enabling IPSO and Setting the Security Classifications

To enable IPSO and set security classifications on an interface, use either of the following commands in interface configuration mode:

| Command                                                                                                                                 | Purpose                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Router(config-if)# <b>ip security dedicated</b> <i>level</i><br><i>authority [authority...]</i>                                         | Sets an interface to the requested IPSO classification and authorities.           |
| Router(config-if)# <b>ip security multilevel</b> <i>level1</i><br><i>[authority1...] to level2 authority2</i><br><i>[authority2...]</i> | Sets an interface to the requested IPSO range of classifications and authorities. |

Use the **no ip security** command to reset an interface to its default state.

### Specifying How IP Security Options Are Processed

To specify how IP security options are processed, use any of the following optional commands in interface configuration mode:

| Command                                                                                             | Purpose                                                                                                      |
|-----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Router(config-if)# <b>ip security ignore-authorities</b>                                            | Enables an interface to ignore the authorities field of all incoming packets.                                |
| Router(config-if)# <b>ip security implicit-labelling</b><br><i>[level authority [authority...]]</i> | Classifies packets that have no IPSO with an implicit security label.                                        |
| Router(config-if)# <b>ip security extended-allowed</b>                                              | Accepts packets on an interface that has an extended security option present.                                |
| Router(config-if)# <b>ip security ad</b>                                                            | Ensures that all packets leaving the router on an interface contain a basic security option.                 |
| Router(config-if)# <b>ip security strip</b>                                                         | Removes any basic security option that might be present on a packet leaving the router through an interface. |



| Command                                                 | Purpose                                                                            |
|---------------------------------------------------------|------------------------------------------------------------------------------------|
| Router(config-if) # <b>ip security first</b>            | Prioritizes security options on a packet.                                          |
| Router(config-if) # <b>ip security reserved-allowed</b> | Treats as valid any packets that have Reserved1 through Reserved4 security levels. |

### Default Values for Command Keywords

To fully comply with IPSO, the default values for the minor keywords have become complex. Default value usages include the following:

- The default for all of the minor keywords is *off*, with the exception of **implicit-labelling** and **add**.
- The default value of **implicit-labelling** is *on* if the interface is “unclassified Genser;” otherwise, it is *off*.
- The default value for **add** is *on* if the interface is not “unclassified Genser;” otherwise, it is *off*.

Table 30 provides a list of all default values.

**Table 30** Default Security Keyword Values

| Interface Type | Level        | Authority | Implicit Labeling | Add IPSO |
|----------------|--------------|-----------|-------------------|----------|
| None           | None         | None      | On                | Off      |
| Dedicated      | Unclassified | Genser    | On                | Off      |
| Dedicated      | Any          | Any       | Off               | On       |
| Multilevel     | Any          | Any       | Off               | On       |

The default value for any interface is “dedicated, unclassified Genser.” Note that this implies implicit labeling. This might seem unusual, but it makes the system entirely transparent to packets without options. This is the setting generated when you specify the **no ip security** interface configuration command.

## Configuring Extended IP Security Options

Cisco’s extended IPSO support is compliant with the Department of Defense Intelligence Information System Network Security for Information Exchange (DNSIX) specification documents. Extended IPSO functionality can unconditionally accept or reject Internet traffic that contains extended security options by comparing those options to configured allowable values. This support allows DNSIX networks to use additional security information to achieve a higher level of security than that achievable with basic IPSO.

Cisco also supports a subset of the security features defined in the DNSIX version 2.1 specification. Specifically, Cisco supports DNSIX definitions of the following:

- How extended IPSO is processed
- Audit trail facility

There are two kinds of extended IPSO fields defined by the DNSIX 2.1 specification and supported by Cisco’s implementation of extended IPSO—Network-level Extended Security Option (NLESO) and Auxiliary Extended Security Option (AESO) fields.

NLESO processing requires that security options be checked against configured allowable information, source, and compartment bit values, and requires that the router be capable of inserting extended security options in the IP header.

AESO is similar to NLESO, except that its contents are not checked and are assumed to be valid if its source is listed in the AESO table.

To configure extended IPSO, complete the tasks in the following sections:

- [Configuring Global Default Settings](#)
- [Attaching ESOs to an Interface](#)
- [Attaching AESOs to an Interface](#)

## Configuring Global Default Settings

To configure global default setting for extended IPSO, including AESOs, use the following command in global configuration mode:

| Command                                                                                | Purpose                                  |
|----------------------------------------------------------------------------------------|------------------------------------------|
| Router(config)# <b>ip security eso-info</b> <i>source compartment-size default-bit</i> | Configures system-wide default settings. |

## Attaching ESOs to an Interface

To specify the minimum and maximum sensitivity levels for an interface, use the following commands in interface configuration mode:

|               | Command                                                                      | Purpose                                              |
|---------------|------------------------------------------------------------------------------|------------------------------------------------------|
| <b>Step 1</b> | Router(config-if)# <b>ip security eso-min</b> <i>source compartment-bits</i> | Sets the minimum sensitivity level for an interface. |
| <b>Step 2</b> | Router(config-if)# <b>ip security eso-max</b> <i>source compartment-bits</i> | Sets the maximum sensitivity level for an interface. |

## Attaching AESOs to an Interface

To specify the extended IPSO sources that are to be treated as AESO sources, use the following command in interface configuration mode:

| Command                                                                   | Purpose                 |
|---------------------------------------------------------------------------|-------------------------|
| Router(config-if)# <b>ip security aeso</b> <i>source compartment-bits</i> | Specifies AESO sources. |

DNSIX version 2.1 causes slow-switching code.

See the “[IPSO Configuration Examples](#)” section at the end of this chapter.

## Configuring the DNSIX Audit Trail Facility

The audit trail facility is a UDP-based protocol that generates an audit trail of IPSO security violations. This facility allows the system to report security failures on incoming and outgoing packets. The Audit Trail Facility sends DNSIX audit trail messages when a datagram is rejected because of IPSO security violations. This feature allows you to configure organization-specific security information.

The DNSIX audit trail facility consists of two protocols:

- DNSIX Message Deliver Protocol (DMDP) provides a basic message-delivery mechanism for all DNSIX elements.
- Network Audit Trail Protocol provides a buffered logging facility for applications to use to generate auditing information. This information is then passed on to DMDP.

To configure the DNSIX auditing facility, complete the tasks in the following sections:

- [Enabling the DNSIX Audit Trail Facility](#)
- [Specifying Hosts to Receive Audit Trail Messages](#)
- [Specifying Transmission Parameters](#)

## Enabling the DNSIX Audit Trail Facility

To enable the DNSIX audit trail facility, use the following command in global configuration mode:

| Command                                                   | Purpose                          |
|-----------------------------------------------------------|----------------------------------|
| Router(config)# <b>dnsix-nat source</b> <i>ip-address</i> | Starts the audit writing module. |

## Specifying Hosts to Receive Audit Trail Messages

To define and change primary and secondary addresses of the host to receive audit messages, use the following commands in global configuration mode:

|               | Command                                                                   | Purpose                                                                                                                                                                                |
|---------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | Router(config)# <b>dnsix-nat primary</b> <i>ip-address</i>                | Specifies the primary address for the audit trail.                                                                                                                                     |
| <b>Step 2</b> | Router(config)# <b>dnsix-nat secondary</b> <i>ip-address</i>              | Specifies the secondary address for the audit trail.                                                                                                                                   |
| <b>Step 3</b> | Router(config)# <b>dnsix-nat authorized-redirection</b> <i>ip-address</i> | Specifies the address of a collection center that is authorized to change primary and secondary addresses. Specified hosts are authorized to change the destination of audit messages. |

## Specifying Transmission Parameters

To specify transmission parameters, use the following commands in global configuration mode:

|               | Command                                                      | Purpose                                                                               |
|---------------|--------------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Step 1</b> | Router(config)# <b>dnsix-nat transmit-count</b> <i>count</i> | Specifies the number of records in a packet before it is sent to a collection center. |
| <b>Step 2</b> | Router(config)# <b>dnsix-dmdp retries</b> <i>count</i>       | Specifies the number of transmit retries for DMDP.                                    |

# IPSO Configuration Examples

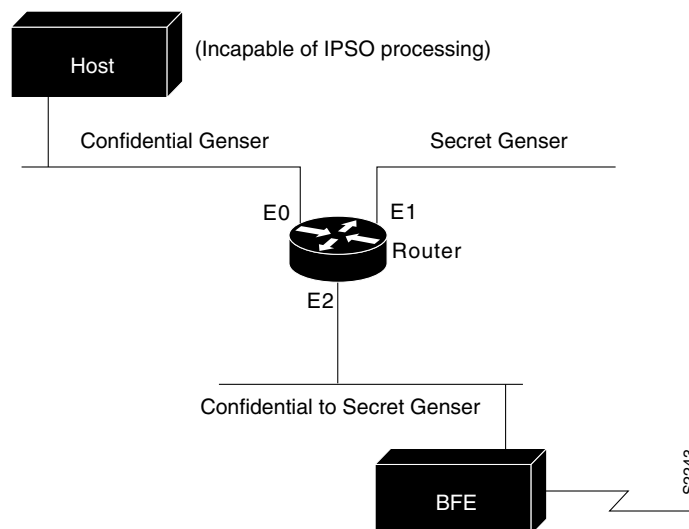
The following sections provide IPSO configuration examples:

- [Example 1](#)
- [Example 2](#)
- [Example 3](#)

## Example 1

In this example, three Ethernet interfaces are presented. These interfaces are running at security levels of Confidential Genser, Secret Genser, and Confidential to Secret Genser, as shown in [Figure 37](#).

**Figure 37** IPSO Security Levels



The following commands set up interfaces for the configuration in [Figure 37](#):

```
interface ethernet 0
 ip security dedicated confidential genser
interface ethernet 1
 ip security dedicated secret genser
interface ethernet 2
 ip security multilevel confidential genser to secret genser
```

It is possible for the setup to be much more complex.

## Example 2

In the following example, there are devices on Ethernet 0 that cannot generate a security option, and so must accept packets without a security option. These hosts do not understand security options; therefore, never place one on such interfaces. Furthermore, there are hosts on the other two networks that are using the extended security option to communicate information, so you must allow these to pass through the system. Finally, there also is a host (a Blacker Front End; see the “Configuring X.25 and LABP” chapter of the *Cisco IOS Wide-Area Networking Configuration Guide* for more information about Blacker emergency mode) on Ethernet 2 that requires the security option to be the first option present, and this condition also must be specified. The new configuration follows.

```
interface ethernet 0
 ip security dedicated confidential genser
 ip security implicit-labelling
 ip security strip
interface ethernet 1
 ip security dedicated secret genser
 ip security extended-allowed
!
interface ethernet 2
 ip security multilevel confidential genser to secret genser
 ip security extended-allowed
 ip security first
```

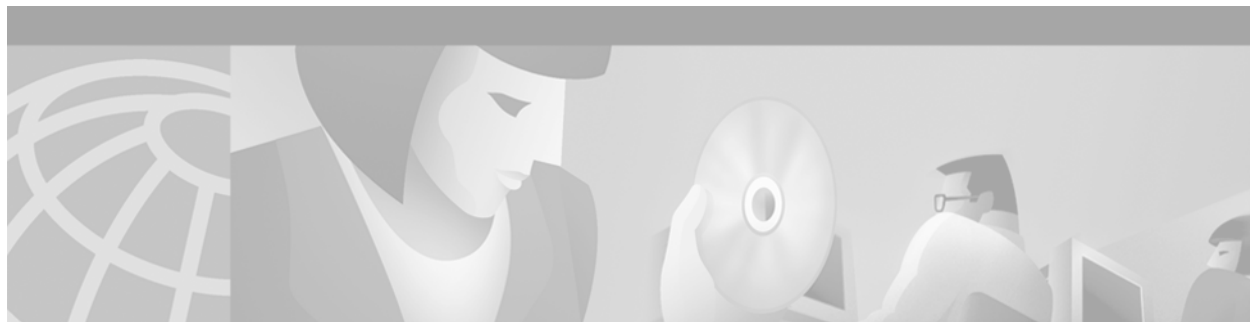
## Example 3

This example shows how to configure a Cisco router with HP-UX CMW DNSIX hosts. The following commands should be configured on each LAN interface of the router for two DNSIX hosts to communicate:

```
ip security multilevel unclassified nsa to top secret nsa
ip security extended allowed
```

DNSIX hosts do not need to know the router's IP addresses, and DNSIX hosts do not need to set up M6RHDB entries for the routers.





# Configuring Unicast Reverse Path Forwarding

---

This chapter describes the Unicast Reverse Path Forwarding (Unicast RPF) feature. The Unicast RPF feature helps to mitigate problems that are caused by malformed or forged IP source addresses that are passing through a router.

For a complete description of the Unicast RPF commands in this chapter, refer to the chapter “Unicast Reverse Path Forwarding Commands” of the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the “Identifying Supported Platforms” section in the chapter “Using Cisco IOS Software.”

## In This Chapter

This chapter has the following sections:

- [About Unicast Reverse Path Forwarding](#)
- [Unicast RPF Configuration Task List](#)
- [Troubleshooting Tips](#)
- [Monitoring and Maintaining Unicast RPF](#)
- [Unicast RPF Configuration Examples](#)

## About Unicast Reverse Path Forwarding

The Unicast RPF feature helps to mitigate problems that are caused by the introduction of malformed or forged (spoofed) IP source addresses into a network by discarding IP packets that lack a verifiable IP source address. For example, a number of common types of denial-of-service (DoS) attacks, including Smurf and Tribal Flood Network (TFN), can take advantage of forged or rapidly changing source IP addresses to allow attackers to thwart efforts to locate or filter the attacks. For Internet service providers (ISPs) that provide public access, Unicast RPF deflects such attacks by forwarding only packets that have source addresses that are valid and consistent with the IP routing table. This action protects the network of the ISP, its customer, and the rest of the Internet.

This section covers the following information:

- [How Unicast RPF Works](#)
- [Implementing Unicast RPF](#)
- [Restrictions](#)
- [Related Features and Technologies](#)
- [Prerequisites to Configuring Unicast RPF](#)

## How Unicast RPF Works

When Unicast RPF is enabled on an interface, the router examines all packets received as input on that interface to make sure that the source address and source interface appear in the routing table and match the interface on which the packet was received. This “look backwards” ability is available only when Cisco express forwarding (CEF) is enabled on the router, because the lookup relies on the presence of the Forwarding Information Base (FIB). CEF generates the FIB as part of its operation.

**Note**

Unicast RPF is an input function and is applied only on the input interface of a router at the upstream end of a connection.

Unicast RPF checks to see if any packet received at a router interface arrives on the best return path (return route) to the source of the packet. Unicast RPF does this by doing a reverse lookup in the CEF table. If the packet was received from one of the best reverse path routes, the packet is forwarded as normal. If there is no reverse path route on the same interface from which the packet was received, it might mean that the source address was modified. If Unicast RPF does not find a reverse path for the packet, the packet is dropped or forwarded, depending on whether an access control list (ACL) is specified in the **ip verify unicast reverse-path** interface configuration command.

**Note**

With Unicast RPF, all equal-cost “best” return paths are considered valid. This means that Unicast RPF works in cases where multiple return paths exist, provided that each path is equal to the others in terms of the routing cost (number of hops, weights, and so on) and as long as the route is in the FIB. Unicast RPF also functions where EIGRP variants are being used and unequal candidate paths back to the source IP address exist.

When a packet is received at the interface where Unicast RPF and ACLs have been configured, the following actions occur:

- Step 1** Input ACLs configured on the inbound interface are checked.
- Step 2** Unicast RPF checks to see if the packet has arrived on the best return path to the source, which it does by doing a reverse lookup in the FIB table.
- Step 3** CEF table (FIB) lookup is carried out for packet forwarding.
- Step 4** Output ACLs are checked on the outbound interface.
- Step 5** The packet is forwarded.

This section provides information about Unicast RPF enhancements:

- [Access Control Lists and Logging](#)
- [Per-Interface Statistics](#)



## Access Control Lists and Logging

If an ACL is specified in the command, then when (and only when) a packet fails the Unicast RPF check, the ACL is checked to see if the packet should be dropped (using a deny statement in the ACL) or forwarded (using a permit statement in the ACL). Whether a packet is dropped or forwarded, the packet is counted in the global IP traffic statistics for Unicast RPF drops and in the interface statistics for Unicast RPF.

If no ACL is specified in the Unicast RPF command, the router drops the forged or malformed packet immediately and no ACL logging occurs. The router and interface Unicast RPF counters are updated.

Unicast RPF events can be logged by specifying the logging option for the ACL entries used by the Unicast RPF command. Using the log information, administrators can see what source addresses are being used in the attack, the time the packets arrived at the interface, and so on.

**Caution**

Logging requires CPU and memory resources. Logging Unicast RPF events for attacks having a high rate of forged packets can degrade the performance of the router.

## Per-Interface Statistics

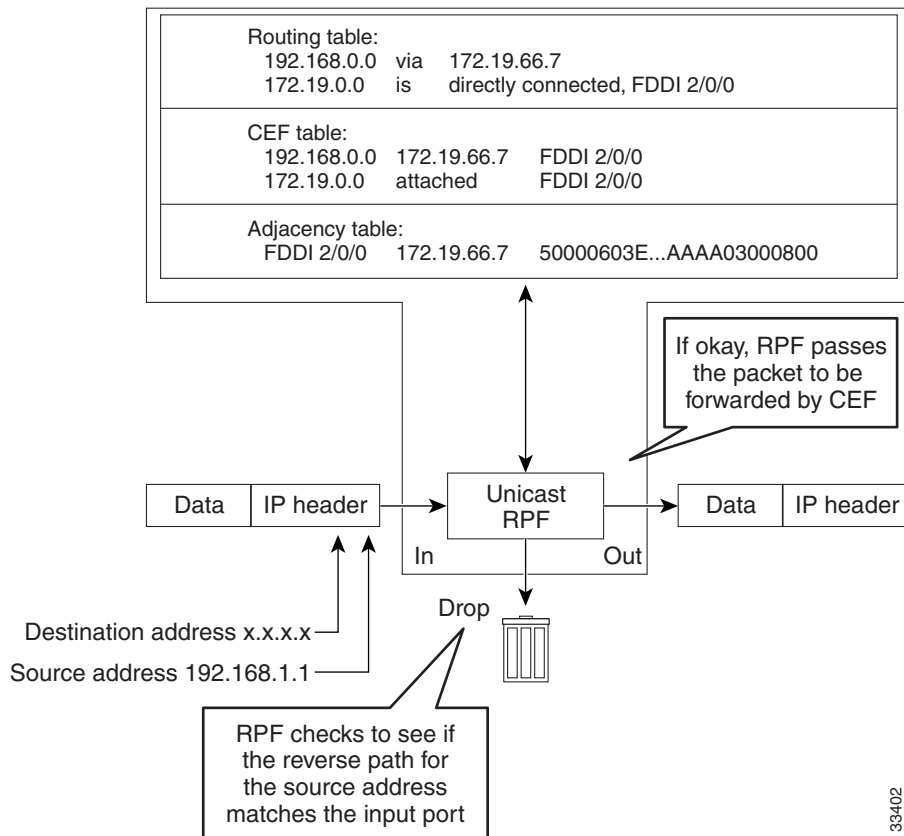
Each time a packet is dropped or forwarded at an interface, that information is counted two ways: globally on the router and at each interface where you have applied Unicast RPF. Global statistics on dropped packets provide information about potential attacks on the network; however, these global statistics do not help to specify which interface is the source of the attack.

Per-interface statistics allow network administrators to track two types of information about malformed packets: Unicast RPF drops and Unicast RPF suppressed drops. Statistics on the number of packets that Unicast RPF drops help to identify the interface that is the entry point of the attack. The Unicast RPF drop count tracks the number of drops at the interface. The Unicast RPF suppressed drop count tracks the number of packets that failed the Unicast RPF check but were forwarded because of the permit permission set up in the ACL. Using the drop count and suppressed drop count statistics, a network administrator can take steps to isolate the attack at a specific interface.

**Note**

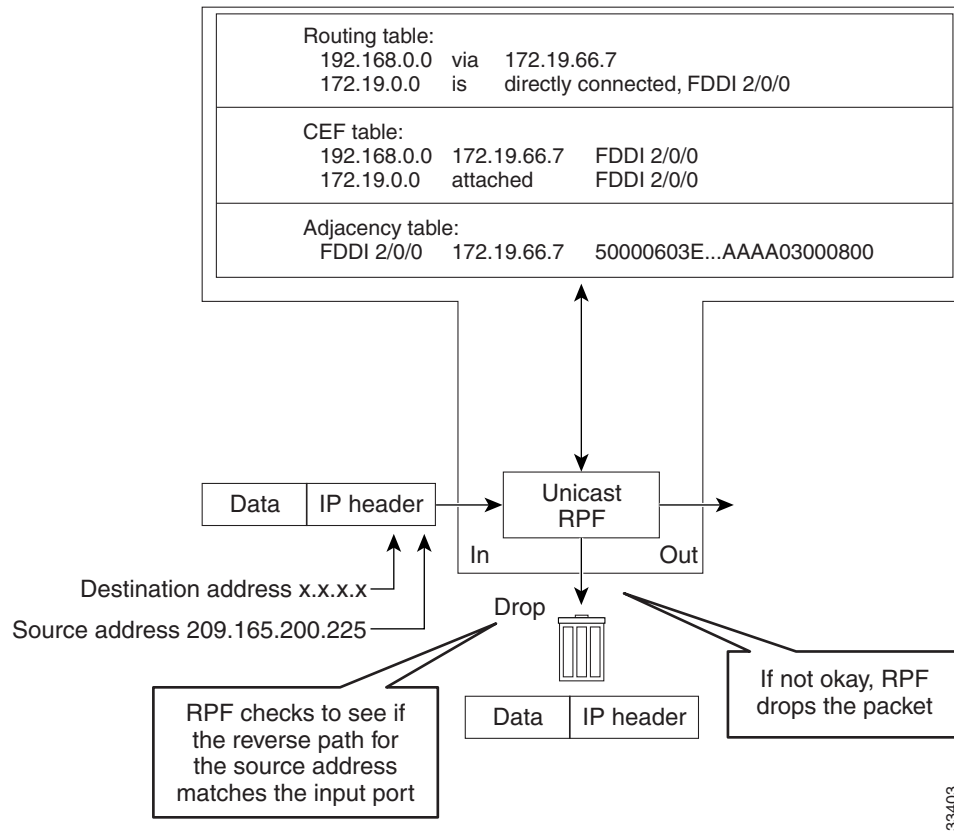
Judicious use of ACL logging can further identify the address or addresses that are being dropped by Unicast RPF.

[Figure 38](#) illustrates how Unicast RPF and CEF work together to validate IP source addresses by verifying packet return paths. In this example, a customer has sent a packet having a source address of 192.168.1.1 from interface FDDI 2/0/0. Unicast RPF checks the FIB to see if 192.168.1.1 has a path to FDDI 2/0/0. If there is a matching path, the packet is forwarded. If there is no matching path, the packet is dropped.

**Figure 38 Unicast RPF Validating IP Source Addresses**

33402

Figure 39 illustrates how Unicast RPF drops packets that fail validation. In this example, a customer has sent a packet having a source address of 209.165.200.225, which is received at interface FDDI 2/0/0. Unicast RPF checks the FIB to see if 209.165.200.225 has a return path to FDDI 2/0/0. If there is a matching path, the packet is forwarded. In this case, there is no reverse entry in the routing table that routes the customer packet back to source address 209.165.200.225 on interface FDDI 2/0/0, and so the packet is dropped.

**Figure 39 Unicast RPF Dropping Packets That Fail Verification**

## Implementing Unicast RPF

Unicast RPF has several key implementation principles:

- The packet must be received at an interface that has the best return path (route) to the packet source (a process called *symmetric routing*). There must be a route in the FIB matching the route to the receiving interface. Adding a route in the FIB can be done via static route, network statement, or dynamic routing. (ACLs permit Unicast RPF to be used when packets are known to be arriving by specific, less optimal asymmetric input paths.)
- IP source addresses at the receiving interface must match the routing entry for the interface.
- Unicast RPF is an input function and is applied only on the input interface of a router at the upstream end of a connection.

Given these implementation principles, Unicast RPF becomes a tool that network administrators can use not only for their customers but also for their downstream network or ISP, even if the downstream network or ISP has other connections to the Internet.



### Caution

Using optional BGP attributes such as weight and local preference, the best path back to the source address can be modified. Modification would affect the operation of Unicast RPF.

This section provides information about the implementation of Unicast RPF:

- [Security Policy and Unicast RPF](#)
- [Where to Use Unicast RPF](#)
- [Routing Table Requirements](#)
- [Where Not to Use Unicast RPF](#)
- [Unicast RPF with BOOTP and DHCP](#)

## Security Policy and Unicast RPF

Consider the following points in determining your policy for deploying Unicast RPF:

- Unicast RPF must be applied at the interface downstream from the larger portion of the network, preferably at the edges of your network.
- The further downstream you apply Unicast RPF, the finer the granularity you have in mitigating address spoofing and in identifying the sources of spoofed addresses. For example, applying Unicast RPF on an aggregation router helps mitigate attacks from many downstream networks or clients and is simple to administer, but it does not help identify the source of the attack. Applying Unicast RPF at the network access server helps limit the scope of the attack and trace the source of the attack; however, deploying Unicast RPF across many sites does add to the administration cost of operating the network.
- The more entities that deploy Unicast RPF across Internet, intranet, and extranet resources, the better the chances of mitigating large-scale network disruptions throughout the Internet community, and the better the chances of tracing the source of an attack.
- Unicast RPF will not inspect IP packets encapsulated in tunnels, such as GRE, LT2P, or PPTP. Unicast RPF must be configured at a home gateway so that Unicast RPF processes network traffic only after the tunneling and encryption layers have been stripped off the packets.

## Where to Use Unicast RPF

Unicast RPF can be used in any “single-homed” environment where there is essentially only one access point out of the network; that is, one upstream connection. Networks having one access point offer the best example of symmetric routing, which means that the interface where a packet enters the network is also the best return path to the source of the IP packet. Unicast RPF is best used at the network perimeter for Internet, intranet, or extranet environments, or in ISP environments for customer network terminations.

The following sections provide a look at implementing Unicast RPF in two network environments:

- [Enterprise Networks with a Single Connection to an ISP](#)
- [Network Access Server Application \(Applying Unicast RPF in PSTN/ISDN PoP Aggregation Routers\)](#)

### Enterprise Networks with a Single Connection to an ISP

In enterprise networks, one objective of using Unicast RPF for filtering traffic at the input interface (a process called *ingress filtering*) is for protection from malformed packets arriving from the Internet. Traditionally, local networks that have one connection to the Internet would use ACLs at the receiving interface to prevent spoofed packets from the Internet from entering their local network.

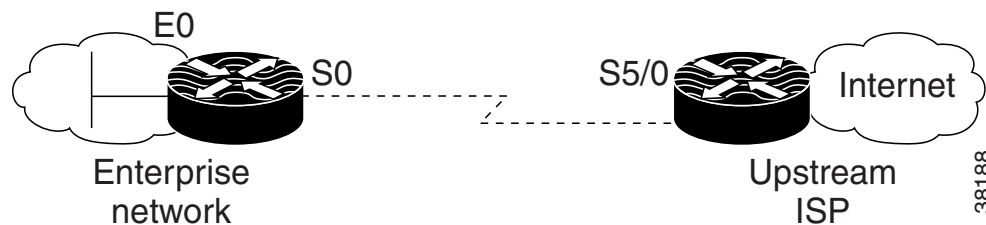
ACLs work well for many single-homed customers; however, there are trade-offs when ACLs are used as ingress filters, including two commonly referenced limitations:

- Packet per second (PPS) performance at very high packet rates
- Maintenance of the ACL (whenever there are new addresses added to the network)

Unicast RPF is one tool that addresses both of these limitations. With Unicast RPF, ingress filtering is done at CEF PPS rates. This processing speed makes a difference when the link is more than 1 Mbps. Additionally, since Unicast RPF uses the FIB, no ACL maintenance is necessary, and thus the administration overhead of traditional ACLs is reduced. The following figure and example demonstrate how Unicast RPF is configured for ingress filtering.

Figure 40 illustrates an enterprise network that has a single link to an upstream ISP. In this example, Unicast RPF is applied at interface S0 on the enterprise router for protection from malformed packets arriving from the Internet. Unicast RPF is also applied at interface S5/0 on the ISP router for protection from malformed packets arriving from the enterprise network.

**Figure 40 Enterprise Network Using Unicast RPF for Ingress Filtering**



Using the topography in Figure 40, a typical configuration (assuming that CEF is turned on) on the ISP router would be as follows:

```
ip cef
interface loopback 0
 description Loopback interface on Gateway Router 2
 ip address 192.168.3.1 255.255.255.255
 no ip redirects
 no ip directed-broadcast
 no ip proxy-arp
interface Serial 5/0
 description 128K HDLC link to ExampleCorp WT50314E R5-0
 bandwidth 128
 ip unnumbered loopback 0
 ip verify unicast reverse-path
 no ip redirects
 no ip directed-broadcast
 no ip proxy-arp
ip route 192.168.10.0 255.255.252.0 Serial 5/0
```

The gateway router configuration of the enterprise network (assuming that CEF is turned on) would look similar to the following:

```
ip cef
interface Ethernet 0
 description ExampleCorp LAN
 ip address 192.168.10.1 255.255.252.0
 no ip redirects
 no ip directed-broadcast
 no ip proxy-arp
```

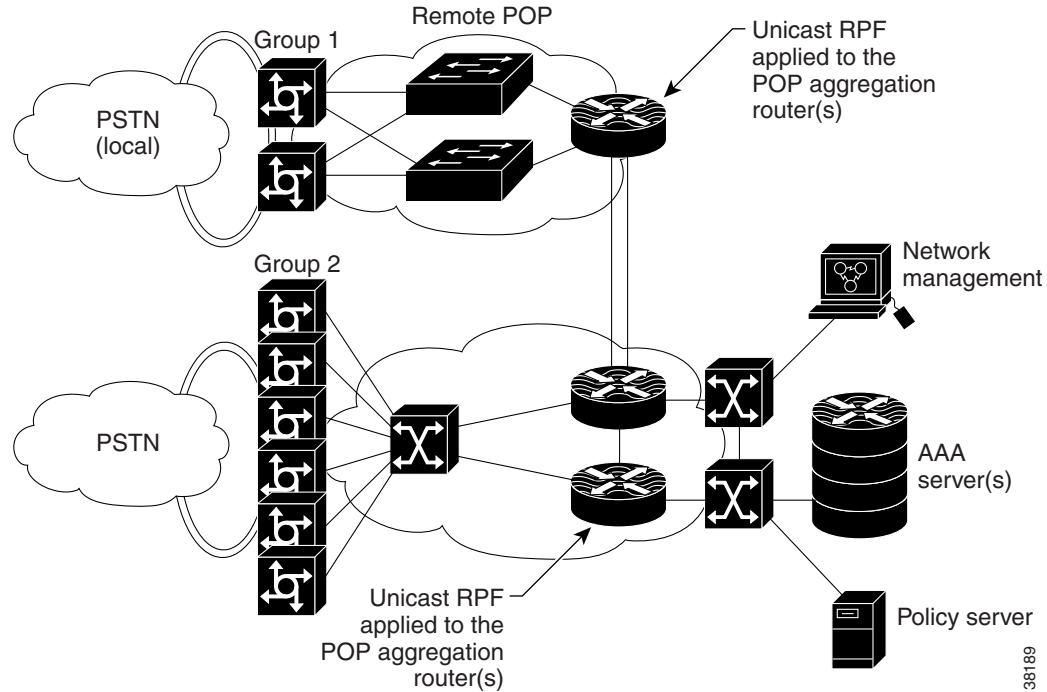
```
interface Serial 0
 description 128K HDLC link to ExampleCorp Internet Inc WT50314E C0
 bandwidth 128
 ip unnumbered ethernet 0
 ip verify unicast reverse-path
 no ip redirects
 no ip directed-broadcast
 no ip proxy-arp
 ip route 0.0.0.0 0.0.0.0 Serial 0
```

Notice that Unicast RPF works with a single default route. There are no additional routes or routing protocols. Network 192.168.10.0/22 is a connected network. Hence, packets coming from the Internet with a source address in the range 192.168.10.0/22 will be dropped by Unicast RPF.

### Network Access Server Application (Applying Unicast RPF in PSTN/ISDN PoP Aggregation Routers)

Aggregation routers are ideal places to use Unicast RPF with single-homed clients. Unicast RPF works equally well on leased-line or PSTN/ISDN/xDSL customer connections into the Internet. In fact, dialup connections are reputed to be the greatest source of DoS attacks using forged IP addresses. As long as the network access server supports CEF, Unicast RPF will work. In this topology, the customer aggregation routers need not have the full Internet routing table. Aggregation routers need the routing prefixes information (IP address block); hence, information configured or redistributed in the Interior Gateway Protocol (IGP) or Internal Border Gateway Protocol (IBGP) (depending on the way that you add customer routes into your network) would be enough for Unicast RPF to do its job.

[Figure 41](#) illustrates the application of Unicast RPF to the aggregation and access routers for an Internet service provider (ISP) point of presence (POP), with the ISP routers providing dialup customer connections. In this example, Unicast RPF is applied upstream from the customer dialup connection router on the receiving (input) interfaces of the ISP aggregation routers.

**Figure 41 Unicast RPF Applied to PSTN/ISDN Customer Connections**

## Routing Table Requirements

To work correctly, Unicast RPF needs proper information in the CEF tables. This requirement does not mean that the router must have the entire Internet routing table. The amount of routing information needed in the CEF tables depends on where Unicast RPF is configured and what functions the router performs in the network. For example, in an ISP environment, a router that is a leased-line aggregation router for customers needs only the information based on the static routes redistributed into the IGP or IBGP (depending on which technique is used in the network). Unicast RPF would be configured on the customer interfaces—hence the requirement for minimal routing information. In another scenario, a single-homed ISP could place Unicast RPF on the gateway link to the Internet. The full Internet routing table would be required. Requiring the full routing table would help protect the ISP from external DoS attacks that use addresses that are not in the Internet routing table.

## Where Not to Use Unicast RPF

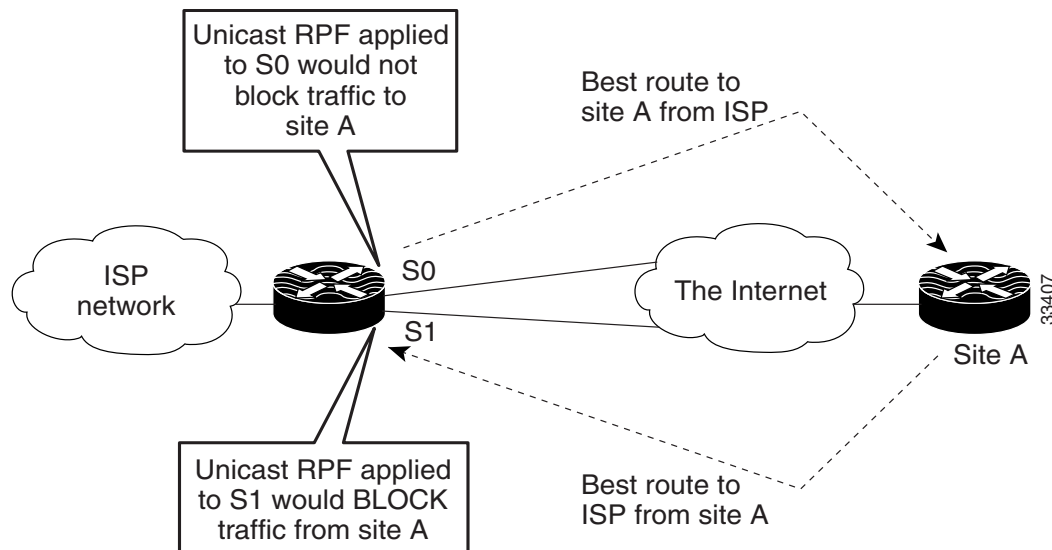
Unicast RPF should not be used on interfaces that are internal to the network. Internal interfaces are likely to have routing asymmetry (see [Figure 42](#)), meaning multiple routes to the source of a packet. Unicast RPF should be applied only where there is natural or configured symmetry. As long as administrators carefully plan which interfaces they activate Unicast RPF on, routing asymmetry is not a serious problem.

For example, routers at the edge of the network of an ISP are more likely to have symmetrical reverse paths than routers that are in the core of the ISP network. Routers that are in the core of the ISP network have no guarantee that the best forwarding path out of the router will be the path selected for packets returning to the router. Hence, it is not recommended that you apply Unicast RPF where there is a chance of asymmetric routing, unless you use ACLs to allow the router to accept incoming packets. ACLs permit

Unicast RPF to be used when packets are known to be arriving by specific, less optimal asymmetric input paths. However, it is simplest to place Unicast RPF only at the edge of a network or, for an ISP, at the customer edge of the network.

Figure 42 illustrates how Unicast RPF can block legitimate traffic in an asymmetrical routing environment.

**Figure 42** *Unicast RPF Blocking Traffic in an Asymmetrical Routing Environment*



## Unicast RPF with BOOTP and DHCP

Unicast RPF will allow packets with 0.0.0.0 source and 255.255.255.255 destination to pass so that Bootstrap Protocol (BOOTP) and Dynamic Host Configuration Protocol (DHCP) functions work properly. This enhancement was added in Cisco IOS Release 12.0 and later, but it is not in Cisco IOS Release 11.1CC.

## Restrictions

There are some basic restrictions to applying Unicast RPF to multihomed clients:

- Clients should not be multihomed to the same router because multihoming defeats the purpose of building a redundant service for the client.
- Customers must ensure that the packets flowing up the link (out to the Internet) match the route advertised out the link. Otherwise, Unicast RPF filters those packets as malformed packets.
- Unicast RPF is available only for platform images that support CEF. Unicast RPF is supported in Cisco IOS Releases 11.1(17)CC and 12.0 and later. It is not available in Cisco IOS Release 11.2 or 11.3.



## Related Features and Technologies

For more information about Unicast RPF-related features and technologies, review the following:

- Unicast RPF requires Cisco express forwarding (CEF) to function properly on the router. For more information about CEF, refer to the *Cisco IOS Switching Services Configuration Guide*.
- Unicast RPF can be more effective at mitigating spoofing attacks when combined with a policy of *ingress* and *egress* filtering using Cisco IOS access control lists (ACLs).
  - Ingress filtering applies filters to traffic received at a network interface from either internal or external networks. With ingress filtering, packets that arrive from other networks or the Internet and that have a source address that matches a local network, private, or broadcast address are dropped. In ISP environments, for example, ingress filtering can apply to traffic received at the router from either the client (customer) or the Internet.
  - Egress filtering applies filters to traffic exiting a network interface (the sending interface). By filtering packets on routers that connect your network to the Internet or to other networks, you can permit only packets with valid source IP addresses to leave your network.

For more information on network filtering, refer to RFC 2267 and to the *Cisco IOS IP Configuration Guide*.

- Cisco IOS software provides additional features that can help mitigate DoS attacks:
  - Committed Access Rate (CAR). CAR allows you to enforce a bandwidth policy against network traffic that matches an access list. For example, CAR allows you to rate-limit what should be low-volume traffic, such as ICMP traffic. To find out more about CAR, refer to the *Cisco IOS Quality of Service Solutions Configuration Guide*.
  - Context-based Access Control (CBAC). CBAC selectively blocks any network traffic not originated by a protected network. CBAC uses timeout and threshold values to manage session state information, helping to determine when to drop sessions that do not become fully established. Setting timeout values for network sessions helps mitigate DoS attacks by freeing up system resources, dropping sessions after a specified amount of time. For more information on CBAC, refer to the *Cisco IOS Security Configuration Guide*.
  - TCP Intercept. The TCP Intercept feature implements software to protect TCP servers from TCP SYN-flooding attacks, which are a type of DoS attack. A SYN-flooding attack occurs when a hacker floods a server with a barrage of requests for connection. Like CBAC, the TCP Intercept feature also uses timeout and threshold values to manage session state information, helping to determine when to drop sessions that do not become fully established. For more information on TCP Intercept, refer to the *Cisco IOS Security Configuration Guide*.

## Prerequisites to Configuring Unicast RPF

Prior to configuring Unicast RPF, configure ACLs:

- Configure standard or extended ACLs to mitigate transmission of invalid IP addresses (perform egress filtering). Permit only valid source addresses to leave your network and get onto the Internet. Prevent all other source addresses from leaving your network for the Internet.
- Configure standard or extended ACLs entries to drop (deny) packets that have invalid source IP addresses (perform ingress filtering). Invalid source IP addresses include the following types:
  - Reserved addresses
  - Loopback addresses
  - Private addresses (RFC 1918, *Address Allocation for Private Internets*)
  - Broadcast addresses (including multicast addresses)
  - Source addresses that fall outside the range of valid addresses associated with the protected network
- Configure standard or extended ACL entries to forward (permit) packets that fail the Unicast RPF checks to allow specific traffic from known asymmetric routed sources.
- Configure ACLs to track Unicast RPF events by adding the logging option into the ACL command. During network attacks, judicious logging of dropped or forwarded packets (suppressed drops) can provide additional information about network attacks.

## Unicast RPF Configuration Task List

The following sections describe the configuration tasks for Unicast RPF. Each task in the list is identified as either optional or required.

- [Configuring Unicast RPF](#) (Required)
- [Verifying Unicast RPF](#) (Optional)

See the section “[Unicast RPF Configuration Examples](#)” at the end of this chapter.

## Configuring Unicast RPF

To use Unicast RPF, you must configure the router for CEF switching or CEF distributed switching. There is no need to configure the input interface for CEF switching because Unicast RPF has been implemented as a search through the FIB using the source IP address. As long as CEF is running on the router, individual interfaces can be configured with other switching modes. Unicast RPF is an input-side function that is enabled on an interface or subinterface that supports any type of encapsulation and operates on IP packets received by the router. It is very important that CEF be turned on globally in the router—Unicast RPF will not work without CEF.

To configure Unicast RPF, use the following commands beginning in global configuration mode:

|               | Command                                                                              | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | Router(config)# <b>ip cef</b><br><br>or<br>Router(config)# <b>ip cef distributed</b> | Enables CEF or distributed CEF on the router. Distributed CEF is required for routers that use a Route Switch Processor (RSP) and Versatile Interface Processor (VIP), which includes Unicast RPF.<br><br>You might want to disable CEF or distributed CEF (dCEF) on a particular interface if that interface is configured with a feature that CEF or dCEF does not support. In this case, you would enable CEF globally, but disable CEF on a specific interface using the <b>no ip route-cache cef</b> interface command, which enables all but that specific interface to use express forwarding. If you have disabled CEF or dCEF operation on an interface and want to reen able it, you can do so by using the <b>ip route-cache cef</b> command in interface configuration mode. |
| <b>Step 2</b> | Router(config-if)# <b>interface type</b>                                             | Selects the input interface on which you want to apply Unicast RPF. This is the receiving interface, which allows Unicast RPF to verify the best return path before forwarding the packet on to the next destination.<br><br>The interface type is specific to your router and the types of interface cards installed on the router. To display a list of available interface types, enter the <b>interface ?</b> command.                                                                                                                                                                                                                                                                                                                                                               |
| <b>Step 3</b> | Router(config-if)# <b>ip verify unicast reverse-path list</b>                        | Enables Unicast RPF on the interface. Use the <i>list</i> option to identify an access list. If the access list denies network access, spoofed packets are dropped at the interface. If the access list permits network access, spoofed packets are forwarded to the destination address. Forwarded packets are counted in the interface statistics. If the access list includes the logging option, information about the spoofed packets is logged to the log server.<br><br>Repeat this step for each access list that you want specify.                                                                                                                                                                                                                                              |
| <b>Step 4</b> | Router(config-if)# <b>exit</b>                                                       | Exits interface configuration mode. Repeat Steps 2 and 3 for each interface on which you want to apply Unicast RPF.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

## Verifying Unicast RPF

To verify that Unicast RPF is operational, use the **show cef interface** command. The following example shows that Unicast RPF is enabled at interface serial2/0/0.

```
Router-3# show cef interface serial 2/0/0

Serial2/0/0 is up (if_number 8)
Internet address is 192.168.10.2/30
ICMP redirects are never sent
Per packet loadbalancing is disabled
!The next line displays Unicast RPF packet dropping information.
IP unicast RPF check is enabled
Inbound access list is not set
Outbound access list is not set
Interface is marked as point to point interface
Packets switched to this interface on linecard are dropped to next slow path
Hardware idb is Serial2/0/0
Fast switching type 4, interface type 6
!The next line displays Unicast RPF packet dropping information.
IP Distributed CEF switching enabled
IP LES Feature Fast switching turbo vector
IP Feature CEF switching turbo vector
Input fast flags 0x40, Output fast flags 0x0, ifindex 7(7)
Slot 2 Slot unit 0 VC -1
Transmit limit accumulator 0x48001A02 (0x48001A02)
IP MTU 1500
```

## Troubleshooting Tips

If you experience problems while using Unicast RPF, check the following items.

### HSRP Failure

Failure to disable Unicast RPF before disabling CEF can cause Hot Standby Router Protocol (HSRP) failure. If you want to disable CEF on the router, you must first disable Unicast RPF. To disable Unicast RPF, see the section “[Monitoring and Maintaining Unicast RPF](#).”

### Dropped Boot Requests

In Cisco IOS Release 11.1(17)CC, Unicast RPF can drop BOOTP request packets that have a source address of 0.0.0.0 due to source address verification at the interface. To enable boot requests to work on the interface, you must use ACLs instead of Unicast RPF.

# Monitoring and Maintaining Unicast RPF

This section describes commands used to monitor and maintain Unicast RPF.

| Command                                                          | Purpose                                                                                                                       |
|------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Router# <b>show ip traffic</b>                                   | Displays global router statistics about Unicast RPF drops and suppressed drops.                                               |
| Router# <b>show ip interface type</b>                            | Displays per-interface statistics about Unicast RPF drops and suppressed drops.                                               |
| Router# <b>show access-lists</b>                                 | Displays the number of matches to a specific ACL.                                                                             |
| Router(config-if)# <b>no ip verify unicast reverse-path list</b> | Disables Unicast RPF at the interface. Use the <i>list</i> option to disable Unicast RPF for a specific ACL at the interface. |



## Caution

To disable CEF, you must first disable Unicast RPF. Failure to disable Unicast RPF before disabling CEF can cause HSRP failure. If you want to disable CEF on the router, you must first disable Unicast RPF.

Unicast RPF counts the number of packets dropped or suppressed because of malformed or forged source addresses. Unicast RPF counts dropped or forwarded packets that include the following global and per-interface information:

- Global Unicast RPF drops
- Per-interface Unicast RPF drops
- Per-interface Unicast RPF suppressed drops

The **show ip traffic** command shows the total number (global count) of dropped or suppressed packets for all interfaces on the router. The Unicast RPF drop count is included in the IP statistics section.

```
Router# show ip traffic
```

IP statistics:

```
Rcvd: 1471590 total, 887368 local destination
 0 format errors, 0 checksum errors, 301274 bad hop count
 0 unknown protocol, 0 not a gateway
 0 security failures, 0 bad options, 0 with options
Opts: 0 end, 0 nop, 0 basic security, 0 loose source route
 0 timestamp, 0 extended security, 0 record route
 0 stream ID, 0 strict source route, 0 alert, 0 other
Frgs: 0 reassembled, 0 timeouts, 0 couldn't reassemble
 0 fragmented, 0 couldn't fragment
Bcast: 205233 received, 0 sent
Mcast: 463292 received, 462118 sent
Sent: 990158 generated, 282938 forwarded
! The second line below ("0 unicast RPF") displays Unicast RPF packet dropping
information.
Drop: 3 encapsulation failed, 0 unresolved, 0 no adjacency
 0 no route, 0 unicast RPF, 0 forced drop
```

A nonzero value for the count of dropped or suppressed packets can mean one of two things:

- Unicast RPF is dropping or suppressing packets that have a bad source address (normal operation).

- Unicast RPF is dropping or suppressing legitimate packets because the route is misconfigured to use Unicast RPF in environments where asymmetric routing exists; that is, where multiple paths can exist as the best return path for a source address.

The **show ip interface** command shows the total of dropped or suppressed packets at a specific interface. If Unicast RPF is configured to use a specific ACL, that ACL information is displayed along with the drop statistics.

```
Router> show ip interface ethernet0/1/1
```

```
Unicast RPF ACL 197
1 unicast RPF drop
1 unicast RPF suppressed drop
```

The **show access-lists** command displays the number of matches found for a specific entry in a specific access list.

```
Router> show access-lists
```

```
Extended IP access list 197
deny ip 192.168.201.0 0.0.0.63 any log-input (1 match)
permit ip 192.168.201.64 0.0.0.63 any log-input (1 match)
deny ip 192.168.201.128 0.0.0.63 any log-input
permit ip 192.168.201.192 0.0.0.63 any log-input
```

## Unicast RPF Configuration Examples

This section provides the following configuration examples:

- [Unicast RPF on a Leased-Line Aggregation Router Example](#)
- [Unicast RPF on the Cisco AS5800 Using Dialup Ports Example](#)
- [Unicast RPF with Inbound and Outbound Filters Example](#)
- [Unicast RPF with ACLs and Logging Example](#)

### Unicast RPF on a Leased-Line Aggregation Router Example

The following commands enable Unicast RPF on a serial interface:

```
ip cef
! or "ip cef distributed" for RSP+VIP based routers
!
interface serial 5/0/0
ip verify unicast reverse-path
```

### Unicast RPF on the Cisco AS5800 Using Dialup Ports Example

The following example enables Unicast RPF on a Cisco AS5800. The **interface Group-Async** command makes it easy to apply Unicast RPF on all the dialup ports.

```
ip cef
!
interface Group-Async1
ip verify unicast reverse-path
```

## Unicast RPF with Inbound and Outbound Filters Example

The following example uses a very simple single-homed ISP to demonstrate the concepts of ingress and egress filters used in conjunction with Unicast RPF. The example illustrates an ISP-allocated classless interdomain routing (CIDR) block 209.165.202.128/28 that has both inbound and outbound filters on the upstream interface. Be aware that ISPs are usually not single-homed. Hence, provisions for asymmetrical flows (when outbound traffic goes out one link and returns via a different link) need to be designed into the filters on the border routers of the ISP.

```
ip cef distributed
!
interface Serial 5/0/0
 description Connection to Upstream ISP
 ip address 209.165.200.225 255.255.255.252
 no ip redirects
 no ip directed-broadcast
 no ip proxy-arp
 ip verify unicast reverse-path
 ip access-group 111 in
 ip access-group 110 out
!
access-list 110 permit ip 209.165.202.128 0.0.0.31 any
access-list 110 deny ip any any log
access-list 111 deny ip host 0.0.0.0 any log
access-list 111 deny ip 127.0.0.0 0.255.255.255 any log
access-list 111 deny ip 10.0.0.0 0.255.255.255 any log
access-list 111 deny ip 172.16.0.0 0.15.255.255 any log
access-list 111 deny ip 192.168.0.0 0.0.255.255 any log
access-list 111 deny ip 209.165.202.128 0.0.0.31 any log
access-list 111 permit ip any any
```

## Unicast RPF with ACLs and Logging Example

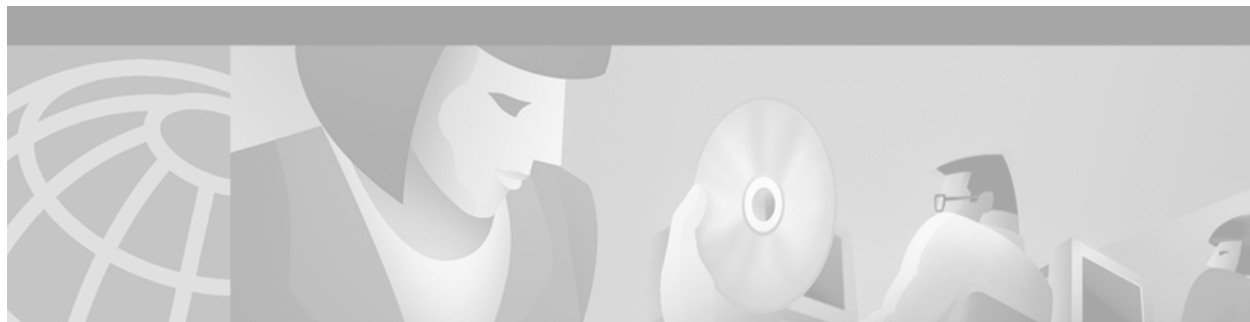
The following example demonstrates the use of ACLs and logging with Unicast RPF. In this example, extended ACL 197 provides entries that deny or permit network traffic for specific address ranges. Unicast RPF is configured on interface Ethernet0 to check packets arriving at that interface.

For example, packets with a source address of 192.168.201.10 arriving at interface Ethernet0 are dropped because of the deny statement in ACL 197. In this case, the ACL information is logged (the logging option is turned on for the ACL entry) and dropped packets are counted per interface and globally. Packets with a source address of 192.168.201.100 arriving at interface Ethernet0 are forwarded because of the permit statement in ACL 197. ACL information about dropped or suppressed packets is logged (logging option turned on for the ACL entry) to the log server.

```
ip cef distributed
!
int eth0/1/1
 ip address 192.168.200.1 255.255.255.0
 ip verify unicast reverse-path 197
!
int eth0/1/2
 ip address 192.168.201.1 255.255.255.0
!
access-list 197 deny ip 192.168.201.0 0.0.0.63 any log-input
access-list 197 permit ip 192.168.201.64 0.0.0.63 any log-input
access-list 197 deny ip 192.168.201.128 0.0.0.63 any log-input
access-list 197 permit ip 192.168.201.192 0.0.0.63 any log-input
access-list 197 deny ip host 0.0.0.0 any log
```







## Configuring Secure Shell

---

This chapter describes the Secure Shell (SSH) feature. The SSH feature consists of an application and a protocol.

For a complete description of the SSH commands in this chapter, refer to the chapter “Secure Shell Commands” of the *Cisco IOS Security Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the “Identifying Supported Platforms” section in the chapter “Using Cisco IOS Software.”

## In This Chapter

This chapter has the following sections:

- [About Secure Shell](#)
- [SSH Configuration Task List](#)
- [Troubleshooting Tips](#)
- [Monitoring and Maintaining SSH](#)
- [SSH Configuration Examples](#)

## About Secure Shell

Secure Shell (SSH) is an application and a protocol that provide a secure replacement to the Berkeley r-tools. The protocol secures the sessions using standard cryptographic mechanisms, and the application can be used similarly to the Berkeley **rexec** and **rsh** tools. There are currently two versions of SSH available: SSH Version 1 and SSH Version 2. Only SSH Version 1 is implemented in the Cisco IOS software.



### Note

---

Hereafter, unless otherwise noted, the term “SSH” will denote “SSH Version 1” only.

---

This rest of this section covers the following information:

- [How SSH Works](#)
- [Restrictions](#)
- [Related Features and Technologies](#)
- [Prerequisites to Configuring SSH](#)

## How SSH Works

This section provides the following information about how SSH works:

- [SSH Server](#)
- [SSH Integrated Client](#)

### SSH Server

The SSH Server feature enables a SSH client to make a secure, encrypted connection to a Cisco router. This connection provides functionality that is similar to that of an inbound Telnet connection. Before SSH, security was limited to Telnet security. SSH allows a strong encryption to be used with the Cisco IOS software authentication. The SSH server in Cisco IOS software will work with publicly and commercially available SSH clients.

### SSH Integrated Client

The SSH Integrated Client feature is an application running over the SSH protocol to provide device authentication and encryption. The SSH client enables a Cisco router to make a secure, encrypted connection to another Cisco router or to any other device running the SSH server. This connection provides functionality that is similar to that of an outbound Telnet connection except that the connection is encrypted. With authentication and encryption, the SSH client allows for a secure communication over an insecure network.

The SSH client in the Cisco IOS software works with publicly and commercially available SSH servers. The SSH client supports the ciphers of Data Encryption Standard (DES), Triple DES (3DES), and password authentication. User authentication is performed like that in the Telnet session to the router. The user authentication mechanisms supported for SSH are RADIUS, TACACS+ and the use of locally stored user names and passwords.

**Note**

---

The SSH client functionality is available only when the SSH server is enabled.

---

## Restrictions

There following are some basic SSH restrictions:

- RSA authentication available in SSH clients is not supported in the SSH server for Cisco IOS software.
- SSH server and SSH client are supported on DES (56-bit) and 3DES (168-bit) data encryption software images only. In DES software images, DES is the only encryption algorithm available. In 3DES software images, both DES and 3DES encryption algorithms are available.
- Execution shell is the only application supported.

## Related Features and Technologies

For more information about SSH-related features and technologies, review the following:

- Authentication, Authorization, and Accounting (AAA) feature. AAA is a suite of network security services that provide the primary framework through which access control can be set up on your Cisco router or access server. For more information on AAA, refer to the Authentication, Authorization, and Accounting chapters earlier in this book and the *Cisco IOS Security Command Reference*.
- IP Security (IPSec) feature. IPSec is a framework of open standards that provides data confidentiality, data integrity, and data authentication between participating peers. IPSec provides these security services at the IP layer. IPSec uses Internet Key Exchange (IKE) to handle negotiation of protocols and algorithms based on local policy and to generate the encryption and authentication keys to be used by IPSec. IPSec can be used to protect one or more data flows between a pair of hosts, between a pair of security gateways, or between a security gateway and a host. For more information on IPSec, refer to the chapter “Configuring IPSec Network Security” and the *Cisco IOS Security Command Reference*.

## Prerequisites to Configuring SSH

Prior to configuring SSH, perform the following tasks:


- Download the required image on your router. (The SSH server requires you to have an IPSec (DES or 3DES) encryption software image from Cisco IOS Release 12.1(1)T downloaded on your router; the SSH client requires you to have an IPSec (DES or 3DES) encryption software image from Cisco IOS Release 12.1(3)T downloaded on your router.) For more information on downloading a software image, refer to the *Cisco IOS Configuration Fundamentals Configuration Guide*.
- Configure a host name and host domain for your router.

To configure a host name and host domain, enter the following commands beginning in global configuration mode:

| Command                                                 | Purpose                                   |
|---------------------------------------------------------|-------------------------------------------|
| Router(config)# <b>hostname</b> <i>hostname</i>         | Configures a host name for your router.   |
| Router(config)# <b>ip domain-name</b> <i>domainname</i> | Configures a host domain for your router. |

- Generate an RSA key pair for your router, which automatically enables SSH.

To generate an RSA key pair, enter the following global configuration command:

| Command                                        | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Router(config)# <b>crypto key generate rsa</b> | <p>Enables the SSH server for local and remote authentication on the router.</p> <p>The recommended minimum modulus size is 1024 bits.</p> <hr/> <p> <b>Note</b> To delete the RSA key-pair, use the <b>crypto key zeroize rsa</b> global configuration command. Once you delete the RSA key-pair, you automatically disable the SSH server.</p> |

- Configure user authentication for local or remote access. You can configure authentication with or without AAA. For more information, refer to the [Configuring Authentication](#), [Configuring Authorization](#), and [Configuring Accounting](#) chapters earlier in the book. See also [Enabling AAA](#).

## SSH Configuration Task List

The following sections describe the configuration tasks for SSH. Each task in the list is identified as either optional or required.

- [Configuring SSH Server](#) (Required)
- [Verifying SSH](#) (Optional)

See the section “[SSH Configuration Examples](#)” at the end of this chapter.

## Configuring SSH Server



### Note

The SSH client feature runs in user EXEC mode and has no specific configuration on the router.



### Note

The SSH commands are optional and are disabled when the SSH server is disabled.

To enable and configure a Cisco Router for SSH, you can configure SSH parameters. If you do not configure SSH parameters, the the default values will be used.

To configure SSH server, use the following command in global configuration mode:

| Command                                                                                                              | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Router(config)# <b>ip ssh</b> {[ <b>timeout</b> <i>seconds</i> ]   [ <b>authentication-retries</b> <i>integer</i> ]} | <p>(Required) Configures SSH control variables on your router.</p> <ul style="list-style-type: none"> <li>You can specify the timeout in seconds, not to exceed 120 seconds. The default is 120. This setting applies to the SSH negotiation phase. Once the EXEC session starts, the standard timeouts configured for the vty apply.</li> </ul> <p>By default, there are 5 vtys defined (0–4), therefore 5 terminal sessions are possible. After the SSH executes a shell, the vty timeout starts. The vty timeout defaults to 10 minutes.</p> <ul style="list-style-type: none"> <li>You can also specify the number of authentication retries, not to exceed 5 authentication retries. The default is 3.</li> </ul> |

## Verifying SSH

To verify that the SSH server is enabled and view the version and configuration data for your SSH connection, use the **show ip ssh** command. The following example shows that SSH is enabled:

```
Router# show ip ssh
```

```
SSH Enabled - version 1.5
Authentication timeout: 120 secs; Authentication retries: 3
```

The following example shows that SSH is disabled:

```
Router# show ip ssh
```

```
%SSH has not been enabled
```

To verify the status of your SSH server connections, use the **show ssh** command. The following example shows the SSH server connections on the router when SSH is enabled:

```
Router# show ssh
Connection Version Encryption State Username
0 1.5 3DES Session Started guest
```

The following example shows that SSH is disabled:

```
Router# show ssh
```

```
%No SSH server connections running.
```

## Troubleshooting Tips

- If your SSH configuration commands are rejected as illegal commands, you have not successfully generated a RSA key pair for your router. Make sure you have specified a host name and domain. Then use the **crypto key generate rsa** command to generate a RSA key pair and enable the SSH server.
- When configuring the RSA key pair, you might encounter the following error messages:
  - No hostname specified  
You must configure a host name for the router using the **hostname** global configuration command. For more information, see [“Prerequisites to Configuring SSH.”](#)
  - No domain specified  
You must configure a host domain for the router using the **ip domain-name** global configuration command. For more information, see [“Prerequisites to Configuring SSH.”](#)
- The number of allowable SSH connections is limited to the maximum number of vty's configured for the router. Each SSH connection will use a vty resource.
- SSH uses either local security or the security protocol that is configured through AAA on your router for user authentication. When configuring AAA, you must ensure that the console is not running under AAA by applying a keyword in the global configuration mode to disable AAA on the console.

## Monitoring and Maintaining SSH

To monitor and maintain your SSH connections, use the following commands in user EXEC mode:

| Command                    | Purpose                                              |
|----------------------------|------------------------------------------------------|
| Router# <b>show ip ssh</b> | Displays the version and configuration data for SSH. |
| Router# <b>show ssh</b>    | Displays the status of SSH server connections.       |

## SSH Configuration Examples

This section provides the following configuration examples, which are output from the **show running configuration** EXEC command on a Cisco 7200, Cisco 7500, and Cisco 12000.

- [SSH on a Cisco 7200 Series Router Example](#)
- [SSH on a Cisco 7500 Series Router Example](#)
- [SSH on a Cisco 1200 Gigabit Switch Router Example](#)



### Note

The **crypto key generate rsa** command is not displayed in the **show running configuration** output.

## SSH on a Cisco 7200 Series Router Example

In the following example, SSH is configured on a Cisco 7200 with a timeout that is not to exceed 60 seconds, and no more than 2 authentication retries. Also, before configuring the SSH server feature on the router, TACACS+ is specified as the method of authentication.

```
aaa new-model
aaa authentication login default tacacs+
aaa authentication login aaa7200kw none
enable password enable7200pw

username mcisco password 0 maryspw
username jcisco password 0 johnspw
ip subnet-zero
no ip domain-lookup
ip domain-name cisco.com
! Enter the ssh commands.
ip ssh time-out 60
ip ssh authentication-retries 2

controller E1 2/0

controller E1 2/1

interface Ethernet1/0
ip address 192.168.110.2 255.255.255.0 secondary
ip address 192.168.109.2 255.255.255.0
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
no keepalive
no cdp enable

interface Ethernet1/1
no ip address
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
shutdown
no cdp enable

interface Ethernet1/2
no ip address
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
shutdown
no cdp enable

no ip classless
ip route 192.168.1.0 255.255.255.0 10.1.10.1
ip route 192.168.9.0 255.255.255.0 10.1.1.1
ip route 192.168.10.0 255.255.255.0 10.1.1.1

map-list atm
ip 10.1.10.1 atm-vc 7 broadcast
no cdp run
```

```

tacacs-server host 192.168.109.216 port 9000
tacacs-server key cisco
radius-server host 192.168.109.216 auth-port 1650 acct-port 1651
radius-server key cisco

line con 0
exec-timeout 0 0
login authentication aaa7200kw
transport input none
line aux 0
line vty 0 4
password enable7200pw

end

```

## SSH on a Cisco 7500 Series Router Example

In the following example, SSH is configured on a Cisco 7500 with a timeout that is not to exceed 60 seconds and no more than 5 authentication retries. Before the SSH Server feature is configured on the router, RADIUS is specified as the method of authentication.

```

aaa new-model
aaa authentication login default radius
aaa authentication login aaa7500kw none
enable password enable7500pw

username mcisco password 0 maryspw
username jcisco password 0 johnspw
ip subnet-zero
no ip cef
no ip domain-lookup
ip domain-name cisco.com
! Enter ssh commands.
ip ssh time-out 60
ip ssh authentication-retries 5

controller E1 3/0
channel-group 0 timeslots 1

controller E1 3/1
channel-group 0 timeslots 1
channel-group 1 timeslots 2

interface Ethernet0/0/0
no ip address
no ip directed-broadcast
no ip route-cache distributed
shutdown

interface Ethernet0/0/1
no ip address
no ip directed-broadcast
no ip route-cache distributed
shutdown
interface Ethernet0/0/2
no ip address
no ip directed-broadcast
no ip route-cache distributed
shutdown

```



```
interface Ethernet0/0/3
no ip address
no ip directed-broadcast
no ip route-cache distributed
shutdown

interface Ethernet1/0
ip address 192.168.110.2 255.255.255.0 secondary
ip address 192.168.109.2 255.255.255.0
no ip directed-broadcast
no ip route-cache
no ip mroute-cache

interface Ethernet1/1
ip address 192.168.109.2 255.255.255.0
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
shutdown

interface Ethernet1/2
no ip address
no ip directed-broadcast
no ip route-cache
no ip mroute-cache

interface Ethernet1/3
no ip address
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
shutdown

interface Ethernet1/4
no ip address
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
shutdown
interface Ethernet1/5
no ip address
no ip directed-broadcast
no ip route-cache
no ip mroute-cache
shutdown

interface Serial2/0
ip address 10.1.1.2 255.0.0.0
no ip directed-broadcast
encapsulation ppp
no ip route-cache
no ip mroute-cache

ip classless
ip route 192.168.9.0 255.255.255.0 10.1.1.1
ip route 192.168.10.0 255.255.255.0 10.1.1.1
```

```

tacacs-server host 192.168.109.216 port 9000
tacacs-server key cisco
radius-server host 192.168.109.216 auth-port 1650 acct-port 1651
radius-server key cisco

line con 0
exec-timeout 0 0
login authentication aaa7500kw
transport input none
line aux 0
transport input all
line vty 0 4

end

```

## SSH on a Cisco 1200 Gigabit Switch Router Example

In the following example, SSH is configured on a Cisco 12000 with a timeout that is not to exceed 60 seconds and no more than 2 authentication retries. Before the SSH Server feature is configured on the router, TACACS+ is specified as the method of authentication.

```

aaa new-model
aaa authentication login default tacacs+ local
aaa authentication login aaa12000kw local
enable password enable12000pw

username mcisco password 0 maryspw
username jcisco password 0 johnspw
redundancy
main-cpu
 auto-sync startup-config
ip subnet-zero
no ip domain-lookup
ip domain-name cisco.com
! Enter ssh commands.
ip ssh time-out 60
ip ssh authentication-retries 2

interface ATM0/0
no ip address
no ip directed-broadcast
no ip route-cache cef
shutdown

interface POS1/0
ip address 10.100.100.2 255.255.255.0
no ip directed-broadcast
encapsulation ppp
no ip route-cache cef
no keepalive
crc 16
no cdp enable

interface POS1/1
no ip address
no ip directed-broadcast
no ip route-cache cef
shutdown
crc 32

```

```
interface POS1/2
no ip address
no ip directed-broadcast
no ip route-cache cef
shutdown
crc 32

interface POS1/3
no ip address
no ip directed-broadcast
no ip route-cache cef
shutdown
crc 32

interface POS2/0
ip address 10.1.1.1 255.255.255.0
no ip directed-broadcast
encapsulation ppp
no ip route-cache cef
crc 16

interface Ethernet0
ip address 172.17.110.91 255.255.255.224
no ip directed-broadcast

router ospf 1
network 0.0.0.0 255.255.255.255 area 0.0.0.0

ip classless
ip route 0.0.0.0 0.0.0.0 172.17.110.65

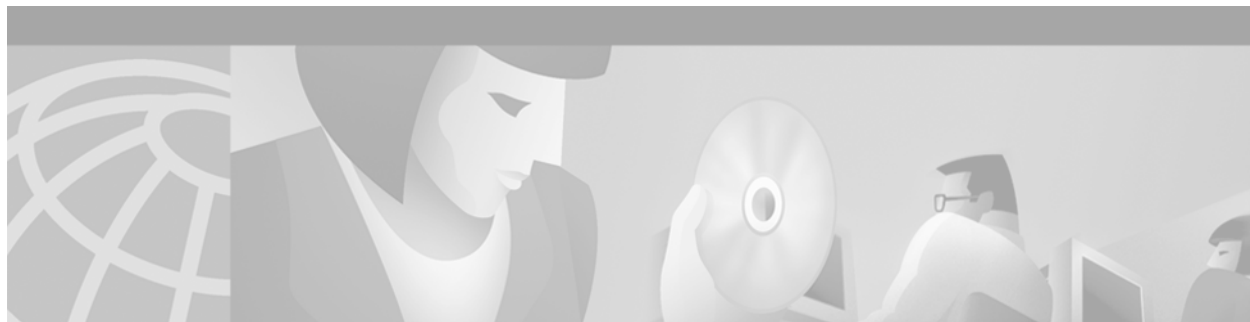
logging trap debugging
tacacs-server host 172.17.116.138
tacacs-server key cisco

radius-server host 172.17.116.138 auth-port 1650 acct-port 1651
radius-server key cisco

line con 0
exec-timeout 0 0
login authentication aaa12000kw
transport input none
line aux 0
line vty 0 4

no scheduler max-task-time
no exception linecard slot 0 sqe-registers
no exception linecard slot 1 sqe-registers
no exception linecard slot 2 sqe-registers
no exception linecard slot 3 sqe-registers
no exception linecard slot 4 sqe-registers
no exception linecard slot 5 sqe-registers
no exception linecard slot 6 sqe-registers
end
```





# RADIUS Attributes Overview

---

Remote Authentication Dial-In User Service (RADIUS) attributes are used to define specific authentication, authorization, and accounting (AAA) elements in a user profile, which is stored on the RADIUS daemon. This appendix lists the RADIUS attributes currently supported.

## In This Appendix

This appendix contains the following sections:

- [RADIUS Attributes Overview](#)
- [RADIUS IETF Attributes](#)
- [Vendor-Proprietary RADIUS Attributes](#)
- [RADIUS Vendor-Specific Attributes \(VSA\)](#)
- [RADIUS Disconnect-Cause Attribute Values](#)

## RADIUS Attributes Overview

This section contains information important to understanding how RADIUS attributes exchange AAA information between a client and server and includes the following sections:

- [IETF Attributes Versus VSAs](#)
- [RADIUS Packet Format](#)
- [RADIUS Files](#)
- [Supporting Documentation](#)

## IETF Attributes Versus VSAs

RADIUS Internet Engineering Task Force (IETF) attributes are the original set of 255 standard attributes that are used to communicate AAA information between a client and a server. Because IETF attributes are standard, the attribute data is predefined and well known; thus all clients and servers who exchange AAA information via IETF attributes must agree on attribute data such as the exact meaning of the attributes and the general bounds of the values for each attribute.

RADIUS vendor-specific attributes (VSAs) derived from one IETF attribute—vendor-specific (attribute 26). Attribute 26 allows a vendor to create an additional 255 attributes however they wish. That is, a vendor can create an attribute that does not match the data of any IETF attribute and encapsulate it behind attribute 26; thus, the newly created attribute is accepted if the user accepts attribute 26.

For more information on VSAs, refer to the section “[RADIUS Vendor-Specific Attributes \(VSA\)](#)” later in this appendix.

## RADIUS Packet Format

The data between a RADIUS server and a RADIUS client is exchanged in RADIUS packets. The data fields are transmitted from left to right.

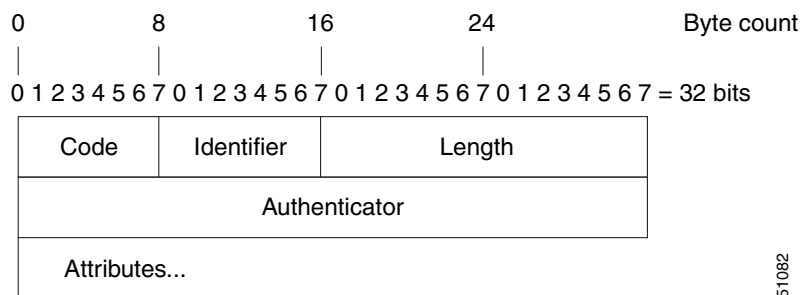
[Figure 43](#) shows the fields within a RADIUS packet.



### Note

For a diagram of VSAs, which is an extension of [Figure 43](#), refer to [Figure 44](#).

**Figure 43 RADIUS Packet Diagram**



Each RADIUS packet contains the following information:

- **Code**—The code field is one octet; it identifies one of the following types of RADIUS packets:
  - Access-Request (1)
  - Access-Accept (2)
  - Access-Reject (3)
  - Accounting-Request (4)
  - Accounting-Response (5)
- **Identifier**—The identifier field is one octet; it helps the RADIUS server match requests and responses and detect duplicate requests.
- **Length**—The length field is two octets; it specifies the length of the entire packet.
- **Authenticator**—The authenticator field is 16 octets. The most significant octet is transmitted first; it is used to authenticate the reply from the RADIUS server. Two types of authenticators are as follows:
  - Request-Authentication: Available in Access-Request and Accounting-Request packets
  - Response-Authenticator: Available in Access-Accept, Access-Reject, Access-Challenge, and Accounting-Response packets

## RADIUS Packet Types

The following list defines the various types of RADIUS packet types that can contain attribute information:

**Access-Request**—Sent from a client to a RADIUS server. The packet contains information that allows the RADIUS server to determine whether to allow access to a specific network access server (NAS), which will allow access to the user. Any user performing authentication *must* submit an Access-Request packet. Once an Access-Request packet is received, the RADIUS server *must* forward a reply.

**Access-Accept**—Once a RADIUS server receives an Access-Request packet, it must send an Access-Accept packet if all attribute values in the Access-Request packet are acceptable. Access-Accept packets provide the configuration information necessary for the client to provide service to the user.

**Access-Reject**—Once a RADIUS server receives an Access-Request packet, it must send an Access-Reject packet if any of the attribute values are not acceptable.

**Access-Challenge**—Once the RADIUS server receives an Access-Accept packet, it can send the client an Access-Challenge packet, which requires a response. If the client does not know how to respond or if the packets are invalid, the RADIUS server discards the packets. If the client responds to the packet, a new Access-Request packet should be sent with the original Access-Request packet.

**Accounting-Request**—Sent from a client to a RADIUS accounting server, which provides accounting information. If the RADIUS server successfully records the Accounting-Request packet, it must submit an Accounting Response packet.

**Accounting-Response**—Sent by the RADIUS accounting server to the client to acknowledge that the Accounting-Request has been received and recorded successfully.

## RADIUS Files

Understanding the types of files used by RADIUS is important for communicating AAA information from a client to a server. Each file defines a level of authentication or authorization for the user: The dictionary file defines which attributes the user's NAS can implement; the clients file defines which users are allowed to make requests to the RADIUS server; the users file defines which user requests the RADIUS server will authenticate based on security and configuration data.

- [Dictionary File](#)
- [Clients File](#)
- [Users File](#)

### Dictionary File

A dictionary file provides a list of attributes that are dependent upon which attributes your NAS supports. However, you can add your own set of attributes to your dictionary for custom solutions. It defines attribute values, thereby allowing you to interpret attribute output such as parsing requests. A dictionary file contains the following information:

- **Name**—The ASCII string “name” of the attribute, such as User-Name.
- **ID**—The numerical “name” of the attribute; for example, User-Name attribute is attribute 1.
- **Value type**—Each attribute can be specified as one of the following five value types:
  - **abinary**—0 to 254 octets.
  - **date**—32-bit value in big endian order. For example, seconds since 00:00:00 GMT, JAN. 1, 1970.

- ipaddr—4 octets in network byte order.
- integer—32-bit value in big endian order (high byte first).
- string—0 to 253 octets.

When the data type for a particular attribute is an integer, you can optionally expand the integer to equate to some string. The follow sample dictionary includes an integer-based attribute and its corresponding values:

```
dictionary sample of integer entry
#
ATTRIBUTE Service-Type 6 integer
VALUE Service-Type Login 1
VALUE Service-Type Framed 2
VALUE Service-Type Callback-Login 3
VALUE Service-Type Callback-Framed 4
VALUE Service-Type Outbound 5
VALUE Service-Type Administrative 6
VALUE Service-Type NAS-Prompt 7
VALUE Service-Type Authenticate-Only 8
VALUE Service-Type Callback-NAS-Prompt 9
VALUE Service-Type Call-Check 10
VALUE Service-Type Callback-Administrative 11
```

## Clients File

A clients file is important because it contains a list of RADIUS clients that are allowed to send authentication and accounting requests to the RADIUS server. To receive authentication, the name and authentication key the client sends the server must be an exact match with the data contained in clients file.

The following is an example of a clients file. The key, as shown in this example, must be the same as the **radius-server key** *SomeSecret* command.

```
#Client Name Key
#-----
10.1.2.3:256 test
nas01 bananas
nas02 MoNkEys
nas07.foo.com SomeSecret
```

## Users File

A RADIUS users file contains an entry for each user that the RADIUS server will authenticate; each entry, which is also referred to as a user profile, establishes an attribute the user can access.

The first line in any user profile is always a “user access” line; that is, the server must check the attributes on the first line before it can grant access to the user. The first line contains the name of the user, which can be up to 252 characters, followed by authentication information such as the password of the user.

Additional lines, which are associated with the user access line, indicate the attribute reply that is sent to the requesting client or server. The attributes sent in the reply must be defined in the dictionary file.

When looking at a user file, please note the the data to the left of the equal (=) character is an attribute defined in the dictionary file, and the data to the right of the equal character is the configuration data.



### Note

A blank line cannot appear anywhere within a user profile.



The following is an example of a RADIUS user profile (Merit Daemon format). In this example, the user name is cisco.com, the password is cisco, and the user can access five tunnel attributes.

```
This user profile includes RADIUS tunneling attributes
cisco.com Password="cisco" Service-Type=Outbound
Tunnel-Type = :1:L2TP
Tunnel-Medium-Type = :1:IP
Tunnel-Server-Endpoint = :1:10.0.0.1
Tunnel-Password = :1:"welcome"
Tunnel-Assignment-ID = :1:"nas"
```

## Supporting Documentation

For more information on RADIUS IETF and Vendor-Proprietary Attributes, refer to the following documents:

- Cisco AAA Implementation Case Study
- “Configuring RADIUS” “Configuring Authentication,” “Configuring Authorization,” and “Configuring Accounting” chapters in this book.

Refer to these chapters for information on how RADIUS is used with AAA.

- IETF RADIUS RFCs
  - RFC 2865, *Remote Authentication Dial In User Service (RADIUS)*
  - RFC 2866, *RADIUS Accounting*
  - RFC 2867, *RADIUS Accounting Modifications for Tunnel Protocol Support*
  - RFC 2868, *RADIUS Attributes for Tunnel Protocol Support*
  - RFC 2869, *RADIUS Extensions*
- RADIUS Vendor-Specific Attributes Voice Implementation Guide

## RADIUS IETF Attributes



### Note

In the Cisco IOS Release 12.2 for RADIUS tunnel attributes, 32 tagged tunnel sets are supported for L2TP.

This section contains the following sections:

- [Supported RADIUS IETF Attributes](#)
- [Comprehensive List of RADIUS Attribute Descriptions](#)

## Supported RADIUS IETF Attributes

[Table 31](#) lists Cisco-supported IETF RADIUS attributes and the Cisco IOS release in which they are implemented. In cases where the attribute has a security server-specific format, the format is specified.

Refer to [Table 32](#) for a description of each listed attribute.

**Note**

Attributes implemented in special (AA) or early development (T) releases will be added to the next mainline image.

**Table 31** *Supported RADIUS IETF Attributes*

| Number | IETF Attribute     | 11.1 | 11.2 | 11.3 | 11.3 AA | 11.3T | 12.0 | 12.1 | 12.2 |
|--------|--------------------|------|------|------|---------|-------|------|------|------|
| 1      | User-Name          | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 2      | User-Password      | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 3      | CHAP-Password      | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 4      | NAS-IP Address     | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 5      | NAS-Port           | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 6      | Service-Type       | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 7      | Framed-Protocol    | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 8      | Framed-IP-Address  | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 9      | Framed-IP-Netmask  | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 10     | Framed-Routing     | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 11     | Filter-Id          | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 12     | Framed-MTU         | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 13     | Framed-Compression | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 14     | Login-IP-Host      | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 15     | Login-Service      | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 16     | Login-TCP-Port     | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 18     | Reply-Message      | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 19     | Callback-Number    | no   | no   | no   | no      | no    | no   | yes  | yes  |
| 20     | Callback-ID        | no   | no   | no   | no      | no    | no   | no   | no   |
| 22     | Framed-Route       | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 23     | Framed-IPX-Network | no   | no   | no   | no      | no    | no   | no   | no   |
| 24     | State              | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 25     | Class              | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 26     | Vendor-Specific    | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 27     | Session-Timeout    | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 28     | Idle-Timeout       | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 29     | Termination-Action | no   | no   | no   | no      | no    | no   | no   | no   |
| 30     | Called-Station-Id  | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 31     | Calling-Station-Id | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 32     | NAS-Identifier     | no   | no   | no   | no      | no    | no   | no   | yes  |
| 33     | Proxy-State        | no   | no   | no   | no      | no    | no   | no   | no   |
| 34     | Login-LAT-Service  | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |

**Table 31 Supported RADIUS IETF Attributes (continued)**

| Number | IETF Attribute                      | 11.1 | 11.2 | 11.3 | 11.3 AA | 11.3T | 12.0 | 12.1 | 12.2 |
|--------|-------------------------------------|------|------|------|---------|-------|------|------|------|
| 35     | Login-LAT-Node                      | no   | no   | no   | no      | no    | no   | no   | yes  |
| 36     | Login-LAT-Group                     | no   | no   | no   | no      | no    | no   | no   | no   |
| 37     | Framed-AppleTalk-Link               | no   | no   | no   | no      | no    | no   | no   | no   |
| 38     | Framed-AppleTalk- Network           | no   | no   | no   | no      | no    | no   | no   | no   |
| 39     | Framed-AppleTalk-Zone               | no   | no   | no   | no      | no    | no   | no   | no   |
| 40     | Acct-Status-Type                    | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 41     | Acct-Delay-Time                     | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 42     | Acct-Input-Octets                   | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 43     | Acct-Output-Octets                  | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 44     | Acct-Session-Id                     | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 45     | Acct-Authentic                      | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 46     | Acct-Session-Time                   | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 47     | Acct-Input-Packets                  | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 48     | Acct-Output-Packets                 | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 49     | Acct-Terminate-Cause                | no   | no   | no   | yes     | yes   | yes  | yes  | yes  |
| 50     | Acct-Multi-Session-Id               | no   | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 51     | Acct-Link-Count                     | no   | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 52     | Acct-Input-Gigawords                | no   | no   | no   | no      | no    | no   | no   | no   |
| 53     | Acct-Output-Gigawords               | no   | no   | no   | no      | no    | no   | no   | no   |
| 55     | Event-Timestamp                     | no   | no   | no   | no      | no    | no   | no   | yes  |
| 60     | CHAP-Challenge                      | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 61     | NAS-Port-Type                       | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 62     | Port-Limit                          | yes  | yes  | yes  | yes     | yes   | yes  | yes  | yes  |
| 63     | Login-LAT-Port                      | no   | no   | no   | no      | no    | no   | no   | no   |
| 64     | Tunnel-Type <sup>1</sup>            | no   | no   | no   | no      | no    | no   | yes  | yes  |
| 65     | Tunnel-Medium-Type <sup>1</sup>     | no   | no   | no   | no      | no    | no   | yes  | yes  |
| 66     | Tunnel-Client-Endpoint              | no   | no   | no   | no      | no    | no   | yes  | yes  |
| 67     | Tunnel-Server-Endpoint <sup>1</sup> | no   | no   | no   | no      | no    | no   | yes  | yes  |
| 68     | Acct-Tunnel-Connection-ID           | no   | no   | no   | no      | no    | no   | yes  | yes  |
| 69     | Tunnel-Password <sup>1</sup>        | no   | no   | no   | no      | no    | no   | yes  | yes  |
| 70     | ARAP-Password                       | no   | no   | no   | no      | no    | no   | no   | no   |
| 71     | ARAP-Features                       | no   | no   | no   | no      | no    | no   | no   | no   |
| 72     | ARAP-Zone-Access                    | no   | no   | no   | no      | no    | no   | no   | no   |
| 73     | ARAP-Security                       | no   | no   | no   | no      | no    | no   | no   | no   |
| 74     | ARAP-Security-Data                  | no   | no   | no   | no      | no    | no   | no   | no   |
| 75     | Password-Retry                      | no   | no   | no   | no      | no    | no   | no   | no   |

**Table 31** Supported RADIUS IETF Attributes (continued)

| Number | IETF Attribute                     | 11.1 | 11.2 | 11.3 | 11.3 AA | 11.3T | 12.0 | 12.1 | 12.2 |
|--------|------------------------------------|------|------|------|---------|-------|------|------|------|
| 76     | Prompt                             | no   | no   | no   | no      | no    | no   | yes  | yes  |
| 77     | Connect-Info                       | no   | no   | no   | no      | no    | no   | no   | yes  |
| 78     | Configuration-Token                | no   | no   | no   | no      | no    | no   | no   | no   |
| 79     | EAP-Message                        | no   | no   | no   | no      | no    | no   | no   | no   |
| 80     | Message-Authenticator              | no   | no   | no   | no      | no    | no   | no   | no   |
| 81     | Tunnel-Private-Group-ID            | no   | no   | no   | no      | no    | no   | no   | no   |
| 82     | Tunnel-Assignment-ID <sup>1</sup>  | no   | no   | no   | no      | no    | no   | yes  | yes  |
| 83     | Tunnel-Preference                  | no   | no   | no   | no      | no    | no   | no   | yes  |
| 84     | ARAP-Challenge-Response            | no   | no   | no   | no      | no    | no   | no   | no   |
| 85     | Acct-Interim-Interval              | no   | no   | no   | no      | no    | no   | yes  | yes  |
| 86     | Acct-Tunnel-Packets-Lost           | no   | no   | no   | no      | no    | no   | no   | no   |
| 87     | NAS-Port-ID                        | no   | no   | no   | no      | no    | no   | no   | no   |
| 88     | Framed-Pool                        | no   | no   | no   | no      | no    | no   | no   | no   |
| 90     | Tunnel-Client-Auth-ID <sup>2</sup> | no   | no   | no   | no      | no    | no   | no   | yes  |
| 91     | Tunnel-Server-Auth-ID              | no   | no   | no   | no      | no    | no   | no   | yes  |
| 200    | IETF-Token-Immediate               | no   | no   | no   | no      | no    | no   | no   | no   |

1. This RADIUS attribute complies with the following two draft IETF documents: RFC 2868 *RADIUS Attributes for Tunnel Protocol Support* and RFC 2867 *RADIUS Accounting Modifications for Tunnel Protocol Support*.
2. This RADIUS attribute complies with RFC 2865 and RFC 2868.

## Comprehensive List of RADIUS Attribute Descriptions

Table 32 lists and describes IETF RADIUS attributes. In cases where the attribute has a security server-specific format, the format is specified.

**Table 32** RADIUS IETF Attributes

| Number | IETF Attribute | Description                                                                                                                                                       |
|--------|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1      | User-Name      | Indicates the name of the user being authenticated by the RADIUS server.                                                                                          |
| 2      | User-Password  | Indicates the user's password or the user's input following an Access-Challenge. Passwords longer than 16 characters are encrypted using RFC 2865 specifications. |
| 3      | CHAP-Password  | Indicates the response value provided by a PPP Challenge-Handshake Authentication Protocol (CHAP) user in response to an Access-Challenge.                        |
| 4      | NAS-IP Address | Specifies the IP address of the network access server that is requesting authentication. The default value is 0.0.0.0/0.                                          |

Table 32 RADIUS IETF Attributes (continued)

| Number | IETF Attribute  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5      | NAS-Port        | <p>Indicates the physical port number of the network access server that is authenticating the user. The NAS-Port value (32 bits) consists of one or two 16-bit values (depending on the setting of the <b>radius-server extended-portnames</b> command). Each 16-bit number should be viewed as a 5-digit decimal integer for interpretation as follows:</p> <p>For asynchronous terminal lines, async network interfaces, and virtual async interfaces, the value is <b>00ttt</b>, where <b>ttt</b> is the line number or async interface unit number.</p> <p>For ordinary synchronous network interface, the value is <b>10xxx</b>.</p> <p>For channels on a primary rate ISDN interface, the value is <b>2ppcc</b>.</p> <p>For channels on a basic rate ISDN interface, the value is <b>3bb0c</b>.</p> <p>For other types of interfaces, the value is <b>6nnss</b>.</p>                                    |
| 6      | Service-Type    | <p>Indicates the type of service requested or the type of service to be provided.</p> <ul style="list-style-type: none"> <li>In a request: <ul style="list-style-type: none"> <li>Framed for known PPP or SLIP connection.</li> <li>Administrative-user for <b>enable</b> command.</li> </ul> </li> <li>In response: <ul style="list-style-type: none"> <li>Login—Make a connection.</li> <li>Framed—Start SLIP or PPP.</li> <li>Administrative User—Start an EXEC or <b>enable ok</b>.</li> <li>Exec User—Start an EXEC session.</li> </ul> </li> </ul> <p>Service type is indicated by a particular numeric value as follows:</p> <ul style="list-style-type: none"> <li>1: Login</li> <li>2: Framed</li> <li>3: Callback-Login</li> <li>4: Callback-Framed</li> <li>5: Outbound</li> <li>6: Administrative</li> <li>7: NAS-Prompt</li> <li>8: Authenticate Only</li> <li>9: Callback-NAS-Prompt</li> </ul> |
| 7      | Framed-Protocol | <p>Indicates the framing to be used for framed access. No other framing is allowed.</p> <p>Framing is indicated by a numeric value as follows:</p> <ul style="list-style-type: none"> <li>1: PPP</li> <li>2: SLIP</li> <li>3: ARA</li> <li>4: Gandalf-proprietary single-link/multilink protocol</li> <li>5: Xylogics-proprietary IPX/SLIP</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

Table 32 RADIUS IETF Attributes (continued)

| Number | IETF Attribute     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8      | Framed-IP-Address  | Indicates the IP address to be configured for the user, by sending the IP address of a user to the RADIUS server in the access-request. To enable this command, use the <b>radius-server attribute 8 include-in-access-req</b> command in global configuration mode.                                                                                                                                                                        |
| 9      | Framed-IP-Netmask  | Indicates the IP netmask to be configured for the user when the user is a router to a network. This attribute value results in a static route being added for Framed-IP-Address with the mask specified.                                                                                                                                                                                                                                    |
| 10     | Framed-Routing     | Indicates the routing method for the user when the user is a router to a network. Only “None” and “Send and Listen” values are supported for this attribute.<br>Routing method is indicated by a numeric value as follows: <ul style="list-style-type: none"> <li>0: None</li> <li>1: Send routing packets</li> <li>2: Listen for routing packets</li> <li>3: Send routing packets and listen for routing packets</li> </ul>                |
| 11     | Filter-Id          | Indicates the name of the filter list for the user and is formatted as follows: %d, %d.in, or %d.out. This attribute is associated with the most recent service-type command. For login and EXEC, use %d or %d.out as the line access list value from 0 to 199. For Framed service, use %d or %d.out as interface output access list, and %d.in for input access list. The numbers are self-encoding to the protocol to which they refer.   |
| 12     | Framed-MTU         | Indicates the maximum transmission unit (MTU) that can be configured for the user when the MTU is not negotiated by PPP or some other means.                                                                                                                                                                                                                                                                                                |
| 13     | Framed-Compression | Indicates a compression protocol used for the link. This attribute results in a “/compress” being added to the PPP or SLIP autocommand generated during EXEC authorization. Not currently implemented for non-EXEC authorization.<br>Compression protocol is indicated by a numeric value as follows: <ul style="list-style-type: none"> <li>0: None</li> <li>1: VJ-TCP/IP header compression</li> <li>2: IPX header compression</li> </ul> |
| 14     | Login-IP-Host      | Indicates the host to which the user will connect when the Login-Service attribute is included. (This begins immediately after login.)                                                                                                                                                                                                                                                                                                      |
| 15     | Login-Service      | Indicates the service that should be used to connect the user to the login host.<br>Service is indicated by a numeric value as follows: <ul style="list-style-type: none"> <li>0: Telnet</li> <li>1: Rlogin</li> <li>2: TCP-Clear</li> <li>3: PortMaster</li> <li>4: LAT</li> </ul>                                                                                                                                                         |
| 16     | Login-TCP-Port     | Defines the TCP port with which the user is to be connected when the Login-Service attribute is also present.                                                                                                                                                                                                                                                                                                                               |

**Table 32** RADIUS IETF Attributes (continued)

| Number | IETF Attribute     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|--------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 18     | Reply-Message      | Indicates text that might be displayed to the user via the RADIUS server. You can include this attribute in user files; however, you cannot exceed a maximum of 16 Reply-Message entries per profile.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 19     | Callback-Number    | Defines a dialing string to be used for callback.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 20     | Callback-ID        | Defines the name (consisting of one or more octets) of a place to be called, to be interpreted by the network access server.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 22     | Framed-Route       | Provides routing information to be configured for the user on this network access server. The RADIUS RFC format (net/bits [router [metric]]) and the old style dotted mask (net mask [router [metric]]) are supported. If the router field is omitted or 0, the peer IP address is used. Metrics are currently ignored. This attribute is access-request packets.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 23     | Framed-IPX-Network | Defines the IPX network number configured for the user.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 24     | State              | Allows state information to be maintained between the network access server and the RADIUS server. This attribute is applicable only to CHAP challenges.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 25     | Class              | (Accounting) Arbitrary value that the network access server includes in all accounting packets for this user if supplied by the RADIUS server.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 26     | Vendor-Specific    | <p>Allows vendors to support their own extended attributes not suitable for general use. The Cisco RADIUS implementation supports one vendor-specific option using the format recommended in the specification. Cisco's vendor-ID is 9, and the supported option has vendor-type 1, which is named "cisco-avpair." The value is a string of the format:</p> <pre>protocol : attribute sep value</pre> <p>"Protocol" is a value of the Cisco "protocol" attribute for a particular type of authorization. "Attribute" and "value" are an appropriate AV pair defined in the Cisco TACACS+ specification, and "sep" is "=" for mandatory attributes and "*" for optional attributes. This allows the full set of features available for TACACS+ authorization to also be used for RADIUS. For example:</p> <pre>cisco-avpair= "ip:addr-pool=first" cisco-avpair= "shell:priv-lvl=15"</pre> <p>The first example causes Cisco's "multiple named ip address pools" feature to be activated during IP authorization (during PPP's IPCP address assignment). The second example causes a user logging in from a network access server to have immediate access to EXEC commands.</p> <p><a href="#">Table 36</a> lists supported vendor-specific RADIUS attributes (IETF attribute 26). The "TACACS+ Attribute-Value Pairs" appendix provides a complete list of supported TACACS+ attribute-value (AV) pairs that can be used with IETF attribute 26. (RFC 2865)</p> |
| 27     | Session-Timeout    | Sets the maximum number of seconds of service to be provided to the user before the session terminates. This attribute value becomes the per-user "absolute timeout."                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 28     | Idle-Timeout       | Sets the maximum number of consecutive seconds of idle connection allowed to the user before the session terminates. This attribute value becomes the per-user "session-timeout."                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

Table 32 RADIUS IETF Attributes (continued)

| Number | IETF Attribute           | Description                                                                                                                                                                                                                                                                                                                                                                  |
|--------|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 29     | Termination-Action       | Termination is indicated by a numeric value as follows: <ul style="list-style-type: none"> <li>0: Default</li> <li>1: RADIUS request</li> </ul>                                                                                                                                                                                                                              |
| 30     | Called-Station-Id        | (Accounting) Allows the network access server to send the telephone number the user called as part of the Access-Request packet (using Dialed Number Identification Service [DNIS] or similar technology). This attribute is only supported on ISDN, and modem calls on the Cisco AS5200 if used with PRI.                                                                   |
| 31     | Calling-Station-Id       | (Accounting) Allows the network access server to send the telephone number the call came from as part of the Access-Request packet (using Automatic Number Identification or similar technology). This attribute has the same value as “remote-addr” from TACACS+. This attribute is only supported on ISDN, and modem calls on the Cisco AS5200 if used with PRI.           |
| 32     | NAS-Identifier           | String identifying the network access server originating the Access-Request. Use the <b>radius-server attribute 32 include-in-access-req</b> global configuration command to send RADIUS attribute 32 in an Access-Request or Accounting-Request. By default, the FQDN is sent in the attribute when the format is not specified.                                            |
| 33     | Proxy-State              | Attribute that can be sent by a proxy server to another server when forwarding Access-Requests; this must be returned unmodified in the Access-Accept, Access-Reject or Access-Challenge and removed by the proxy server before sending the response to the network access server.                                                                                           |
| 34     | Login-LAT-Service        | Indicates the system with which the user is to be connected by LAT. This attribute is only available in the EXEC mode.                                                                                                                                                                                                                                                       |
| 35     | Login-LAT-Node           | Indicates the node with which the user is to be automatically connected by LAT.                                                                                                                                                                                                                                                                                              |
| 36     | Login-LAT-Group          | Identifies the LAT group codes that this user is authorized to use.                                                                                                                                                                                                                                                                                                          |
| 37     | Framed-AppleTalk-Link    | Indicates the AppleTalk network number that should be used for serial links to the user, which is another AppleTalk router.                                                                                                                                                                                                                                                  |
| 38     | Framed-AppleTalk-Network | Indicates the AppleTalk network number that the network access server uses to allocate an AppleTalk node for the user.                                                                                                                                                                                                                                                       |
| 39     | Framed-AppleTalk-Zone    | Indicates the AppleTalk Default Zone to be used for this user.                                                                                                                                                                                                                                                                                                               |
| 40     | Acct-Status-Type         | (Accounting) Indicates whether this Accounting-Request marks the beginning of the user service (start) or the end (stop).                                                                                                                                                                                                                                                    |
| 41     | Acct-Delay-Time          | (Accounting) Indicates how many seconds the client has been trying to send a particular record.                                                                                                                                                                                                                                                                              |
| 42     | Acct-Input-Octets        | (Accounting) Indicates how many octets have been received from the port over the course of this service being provided.                                                                                                                                                                                                                                                      |
| 43     | Acct-Output-Octets       | (Accounting) Indicates how many octets have been sent to the port in the course of delivering this service.                                                                                                                                                                                                                                                                  |
| 44     | Acct-Session-Id          | (Accounting) A unique accounting identifier that makes it easy to match start and stop records in a log file. Acct-Session ID numbers restart at 1 each time the router is power cycled or the software is reloaded. To send this attribute in access-request packets, use the <b>radius-server attribute 44 include-in-access-req</b> command in global configuration mode. |



Table 32 RADIUS IETF Attributes (continued)

| Number | IETF Attribute        | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 45     | Acct-Authentic        | (Accounting) Indicates how the user was authenticated, whether by RADIUS, the network access server itself, or another remote authentication protocol. This attribute is set to “radius” for users authenticated by RADIUS; “remote” for TACACS+ and Kerberos; or “local” for local, enable, line, and if-needed methods. For all other methods, the attribute is omitted.                                                                                                                                                                                                                                                                                                                                                                                 |
| 46     | Acct-Session-Time     | (Accounting) Indicates how long (in seconds) the user has received service.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 47     | Acct-Input-Packets    | (Accounting) Indicates how many packets have been received from the port over the course of this service being provided to a framed user.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 48     | Acct-Output-Packets   | (Accounting) Indicates how many packets have been sent to the port in the course of delivering this service to a framed user.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 49     | Acct-Terminate-Cause  | <p>(Accounting) Reports details on why the connection was terminated. Termination causes are indicated by a numeric value as follows:</p> <ol style="list-style-type: none"> <li>1. User request</li> <li>2. Lost carrier</li> <li>3. Lost service</li> <li>4. Idle timeout</li> <li>5. Session timeout</li> <li>6. Admin reset</li> <li>7. Admin reboot</li> <li>8. Port error</li> <li>9. NAS error</li> <li>10. NAS request</li> <li>11. NAS reboot</li> <li>12. Port unneeded</li> <li>13. Port pre-empted</li> <li>14. Port suspended</li> <li>15. Service unavailable</li> <li>16. Callback</li> <li>17. User error</li> <li>18. Host request</li> </ol> <p><b>Note</b> For attribute 49, Cisco IOS supports values 1 to 6, 9, 12, and 15 to 18.</p> |
| 50     | Acct-Multi-Session-Id | <p>(Accounting) A unique accounting identifier used to link multiple related sessions in a log file.</p> <p>Each linked session in a multilink session has a unique Acct-Session-Id value, but shares the same Acct-Multi-Session-Id.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 51     | Acct-Link-Count       | (Accounting) Indicates the number of links known in a given multilink session at the time an accounting record is generated. The network access server can include this attribute in any accounting request that might have multiple links.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

Table 32 RADIUS IETF Attributes (continued)

| Number | IETF Attribute                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 52     | Acct-Input-Gigawords            | Indicates how many times the Acct-Input-Octets counter has wrapped around $2^{32}$ over the course of the provided service.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 53     | Acct-Output-Gigawords           | Indicates how many times the Acct-Output-Octets counter has wrapped around $2^{32}$ while delivering service.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 55     | Event-Timestamp                 | <p>Records the time that the event occurred on the NAS; the timestamp sent in attribute 55 is in seconds since January 1, 1970 00:00 UTC. To send RADIUS attribute 55 in accounting packets, use the <b>radius-server attribute 55 include-in-acct-req</b> command.</p> <p><b>Note</b> Before the Event-Timestamp attribute can be sent in accounting packets, you <i>must</i> configure the clock on the router. (For information on setting the clock on your router, refer to section “Performing Basic System Management” in the chapter “System Management” of the <i>Cisco IOS Configuration Fundamentals Configuration Guide</i>.)</p> <p>To avoid configuring the clock on the router every time the router is reloaded, you can enable the <b>clock calendar-valid</b> command. (For information on this command, refer to the chapter “Basic System Management Commands” in the <i>Cisco IOS Configuration Fundamentals Command Reference</i>.)</p> |
| 60     | CHAP-Challenge                  | Contains the Challenge Handshake Authentication Protocol challenge sent by the network access server to a PPP CHAP user.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 61     | NAS-Port-Type                   | <p>Indicates the type of physical port the network access server is using to authenticate the user. Physical ports are indicated by a numeric value as follows:</p> <ul style="list-style-type: none"> <li>• 0: Asynchronous</li> <li>• 1: Synchronous</li> <li>• 2: ISDN-Synchronous</li> <li>• 3: ISDN-Asynchronous (V.120)</li> <li>• 4: ISDN-Asynchronous (V.110)</li> <li>• 5: Virtual</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 62     | Port-Limit                      | Sets the maximum number of ports provided to the user by the NAS.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 63     | Login-LAT-Port                  | Defines the port with which the user is to be connected by LAT.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 64     | Tunnel-Type <sup>1</sup>        | Indicates the tunneling protocol(s) used. Cisco IOS software supports two possible values for this attribute: L2TP and L2F. If this attribute is not set, L2F is used as a default.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 65     | Tunnel-Medium-Type <sup>1</sup> | Indicates the transport medium type to use to create a tunnel. This attribute has only one available value for this release: IP. If no value is set for this attribute, IP is used as the default.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

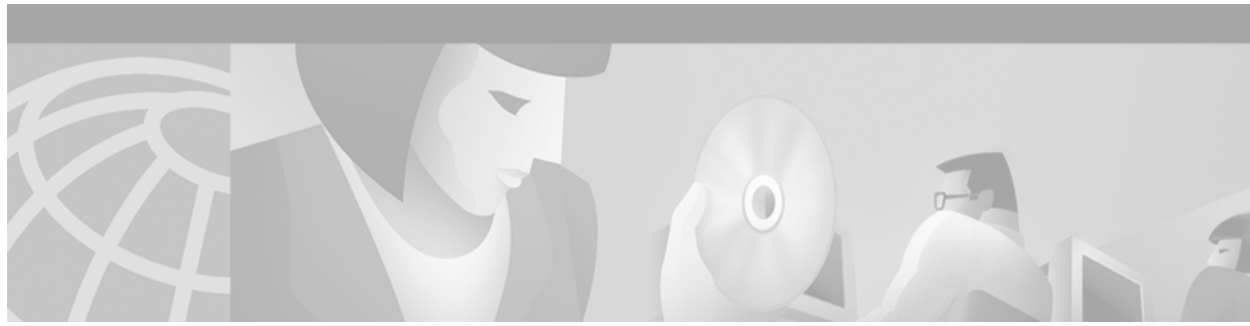
Table 32 RADIUS IETF Attributes (continued)

| Number | IETF Attribute                      | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 66     | Tunnel-Client-Endpoint              | <p>Contains the address of the initiator end of the tunnel. It <i>may</i> be included in both Access-Request and Access-Accept packets to indicate the address from which a new tunnel is to be initiated. If the Tunnel-Client-Endpoint attribute is included in an Access-Request packet, the RADIUS server should take the value as a hint; the server is not obligated to honor the hint, however. This attribute <i>should</i> be included in Accounting-Request packets that contain Acct-Status-Type attributes with values of either Start or Stop, in which case it indicates the address from which the tunnel was initiated. This attribute, along with the Tunnel-Server-Endpoint and Acct-Tunnel-Connection-ID attributes, may be used to provide a globally unique means to identify a tunnel for accounting and auditing purposes.</p> <p>An enhancement has been added for the network access server to accept a value of 127.0.0.X for this attribute such that:</p> <p>127.0.0.0 would indicate that loopback0 IP address is to be used<br/> 127.0.0.1 would indicate that loopback1 IP address is to be used<br/> ...<br/> 127.0.0.X would indicate that loopbackX IP address is to be used</p> <p>for the actual tunnel client endpoint IP address. This enhancement adds scalability across multiple network access servers.</p> |
| 67     | Tunnel-Server-Endpoint <sup>1</sup> | Indicates the address of the server end of the tunnel. The format of this attribute varies depending on the value of Tunnel-Medium-Type. Because this release only supports IP as a tunnel medium type, the IP address or the host name of LNS is valid for this attribute.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 68     | Acct-Tunnel-Connection-ID           | Indicates the identifier assigned to the tunnel session. This attribute <i>should</i> be included in Accounting-Request packets that contain an Acct-Status-Type attribute having the value Start, Stop, or any of the values described above. This attribute, along with the Tunnel-Client-Endpoint and Tunnel-Server-Endpoint attributes, may be used to provide a means to uniquely identify a tunnel session for auditing purposes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 69     | Tunnel-Password <sup>1</sup>        | <p>Defines the password to be used to authenticate to a remote server. This attribute is converted into different AAA attributes based on the value of Tunnel-Type: AAA_ATTR_l2tp_tunnel_pw (L2TP), AAA_ATTR_nas_password (L2F), and AAA_ATTR_gw_password (L2F).</p> <p>By default, all passwords received are encrypted, which can cause authorization failures when a NAS attempts to decrypt a non-encrypted password. To enable attribute 69 to receive non-encrypted passwords, use the <b>radius-server attribute 69 clear</b> global configuration command.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 70     | ARAP-Password                       | Identifies an Access-Request packet containing a Framed-Protocol of ARAP.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 71     | ARAP-Features                       | Includes password information that the NAS should send to the user in an ARAP "feature flags" packet.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 72     | ARAP-Zone-Access                    | Indicates how the ARAP zone list for the user should be used.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 73     | ARAP-Security                       | Identifies the ARAP Security Module to be used in an Access-Challenge packet.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 74     | ARAP-Security-Data                  | Contains the actual security module challenge or response. It can be found in Access-Challenge and Access-Request packets.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 75     | Password-Retry                      | Indicates how many times a user may attempt authentication before being disconnected.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

Table 32 RADIUS IETF Attributes (continued)

| Number | IETF Attribute                    | Description                                                                                                                                                                                                                                                                                                                                                                                     |
|--------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 76     | Prompt                            | Indicates to the NAS whether it should echo the user's response as it is entered or not echo it. (0=no echo, 1=echo)                                                                                                                                                                                                                                                                            |
| 77     | Connect-Info                      | Provides additional call information for modem calls. This attribute is generated in start and stop accounting records.                                                                                                                                                                                                                                                                         |
| 78     | Configuration-Token               | Indicates a type of user profile to be used. This attribute should be used in large distributed authentication networks based on proxy. It is sent from a RADIUS Proxy Server to a RADIUS Proxy Client in an Access-Accept; it should not be sent to a NAS.                                                                                                                                     |
| 79     | EAP-Message                       | Encapsulates Extended Access Protocol (EAP) packets that allow the NAS to authenticate dial-in users via EAP without having to understand the EAP protocol.                                                                                                                                                                                                                                     |
| 80     | Message-Authenticator             | Prevents spoofing Access-Requests using CHAP, ARAP, or EAP authentication methods.                                                                                                                                                                                                                                                                                                              |
| 81     | Tunnel-Private-Group-ID           | Indicates the group ID for a particular tunneled session.                                                                                                                                                                                                                                                                                                                                       |
| 82     | Tunnel-Assignment-ID <sup>1</sup> | Indicates to the tunnel initiator the particular tunnel to which a session is assigned.                                                                                                                                                                                                                                                                                                         |
| 83     | Tunnel-Preference                 | Indicates the relative preference assigned to each tunnel. This attribute should be included if more than one set of tunneling attributes is returned by the RADIUS server to the tunnel initiator.                                                                                                                                                                                             |
| 84     | ARAP-Challenge-Response           | Contains the response to the challenge of the dial-in client.                                                                                                                                                                                                                                                                                                                                   |
| 85     | Acct-Interim-Interval             | Indicates the number of seconds between each interim update in seconds for this specific session. This value can only appear in the Access-Accept message.                                                                                                                                                                                                                                      |
| 86     | Acct-Tunnel-Packets-Lost          | Indicates the number of packets lost on a given link. This attribute should be included in Accounting-Request packets that contain an Acct-Status-Type attribute having the value Tunnel-Link-Stop.                                                                                                                                                                                             |
| 87     | NAS-Port-ID                       | Contains a text string which identifies the port of the NAS that is authenticating the user.                                                                                                                                                                                                                                                                                                    |
| 88     | Framed-Pool                       | Contains the name of an assigned address pool that should be used to assign an address for the user. If a NAS does not support multiple address pools, the NAS should ignore this attribute.                                                                                                                                                                                                    |
| 90     | Tunnel-Client-Auth-ID             | Specifies the name used by the tunnel initiator (also known as the NAS) when authenticating tunnel setup with the tunnel terminator. Supports L2F and L2TP protocols.                                                                                                                                                                                                                           |
| 91     | Tunnel-Server-Auth-ID             | Specifies the name used by the tunnel terminator (also known as the Home Gateway) when authenticating tunnel setup with the tunnel initiator. Supports L2F and L2TP protocols.                                                                                                                                                                                                                  |
| 200    | IETF-Token-Immediate              | <p>Determines how RADIUS treats passwords received from login-users when their file entry specifies a hand-held security card server.</p> <p>The value for this attribute is indicated by a numeric value as follows:</p> <ul style="list-style-type: none"> <li>0: No, meaning that the password is ignored.</li> <li>1: Yes, meaning that the password is used for authentication.</li> </ul> |

1. This RADIUS attribute complies with the following two IETF documents: RFC 2868, *RADIUS Attributes for Tunnel Protocol Support* and RFC 2867, *RADIUS Accounting Modifications for Tunnel Protocol Support*.



## Vendor-Proprietary RADIUS Attributes

Although an IETF draft standard for RADIUS specifies a method for communicating vendor-proprietary information between the network access server and the RADIUS server, some vendors have extended the RADIUS attribute set for specific applications.

This section contains the following sections:

- [Supported Vendor-Proprietary RADIUS Attributes](#)
- [Comprehensive List of Vendor-Proprietary RADIUS Attribute Descriptions](#)

## Supported Vendor-Proprietary RADIUS Attributes

[Table 33](#) lists Cisco-supported vendor-proprietary RADIUS attributes and the Cisco IOS release in which they are implemented. In cases where the attribute has a security server-specific format, the format is specified. Refer to [Table 34](#) for a list of descriptions.



**Note**

Attributes implemented in special (AA) or early development (T) releases will be added to the next mainline image.

**Table 33**     *Supported Vendor-Proprietary RADIUS Attributes*

| Number | Vendor-Proprietary Attribute | 11.1 | 11.2 | 11.3 | 11.3AA | 11.3T | 12.0 | 12.1 | 12.2 |
|--------|------------------------------|------|------|------|--------|-------|------|------|------|
| 17     | Change-Password              | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 21     | Password-Expiration          | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 68     | Tunnel-ID                    | no   | no   | no   | no     | no    | no   | no   | yes  |
| 108    | My-Endpoint-Disc-Alias       | no   | no   | no   | no     | no    | no   | no   | no   |
| 109    | My-Name-Alias                | no   | no   | no   | no     | no    | no   | no   | no   |
| 110    | Remote-FW                    | no   | no   | no   | no     | no    | no   | no   | no   |
| 111    | Multicast-GLeave-Delay       | no   | no   | no   | no     | no    | no   | no   | no   |
| 112    | CBCP-Enable                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 113    | CBCP-Mode                    | no   | no   | no   | no     | no    | no   | no   | no   |
| 114    | CBCP-Delay                   | no   | no   | no   | no     | no    | no   | no   | no   |
| 115    | CBCP-Trunk-Group             | no   | no   | no   | no     | no    | no   | no   | no   |
| 116    | Appletalk-Route              | no   | no   | no   | no     | no    | no   | no   | no   |
| 117    | Appletalk-Peer-Mode          | no   | no   | no   | no     | no    | no   | no   | no   |

**Table 33** Supported Vendor-Proprietary RADIUS Attributes (continued)

| Number | Vendor-Proprietary Attribute | 11.1 | 11.2 | 11.3 | 11.3AA | 11.3T | 12.0 | 12.1 | 12.2 |
|--------|------------------------------|------|------|------|--------|-------|------|------|------|
| 118    | Route-Appletalk              | no   | no   | no   | no     | no    | no   | no   | no   |
| 119    | FCP-Parameter                | no   | no   | no   | no     | no    | no   | no   | no   |
| 120    | Modem-PortNo                 | no   | no   | no   | no     | no    | no   | no   | no   |
| 121    | Modem-SlotNo                 | no   | no   | no   | no     | no    | no   | no   | no   |
| 122    | Modem-ShelfNo                | no   | no   | no   | no     | no    | no   | no   | no   |
| 123    | Call-Attempt-Limit           | no   | no   | no   | no     | no    | no   | no   | no   |
| 124    | Call-Block-Duration          | no   | no   | no   | no     | no    | no   | no   | no   |
| 125    | Maximum-Call-Duration        | no   | no   | no   | no     | no    | no   | no   | no   |
| 126    | Router-Preference            | no   | no   | no   | no     | no    | no   | no   | no   |
| 127    | Tunneling-Protocol           | no   | no   | no   | no     | no    | no   | no   | no   |
| 128    | Shared-Profile-Enable        | no   | no   | no   | no     | no    | no   | no   | no   |
| 129    | Primary-Home-Agent           | no   | no   | no   | no     | no    | no   | no   | no   |
| 130    | Secondary-Home-Agent         | no   | no   | no   | no     | no    | no   | no   | no   |
| 131    | Dialout-Allowed              | no   | no   | no   | no     | no    | no   | no   | no   |
| 133    | BACP-Enable                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 134    | DHCP-Maximum-Leases          | no   | no   | no   | no     | no    | no   | no   | no   |
| 135    | Primary-DNS-Server           | no   | no   | no   | no     | yes   | yes  | yes  | yes  |
| 136    | Secondary-DNS-Server         | no   | no   | no   | no     | yes   | yes  | yes  | yes  |
| 137    | Client-Assign-DNS            | no   | no   | no   | no     | no    | no   | no   | no   |
| 138    | User-Acct-Type               | no   | no   | no   | no     | no    | no   | no   | no   |
| 139    | User-Acct-Host               | no   | no   | no   | no     | no    | no   | no   | no   |
| 140    | User-Acct-Port               | no   | no   | no   | no     | no    | no   | no   | no   |
| 141    | User-Acct-Key                | no   | no   | no   | no     | no    | no   | no   | no   |
| 142    | User-Acct-Base               | no   | no   | no   | no     | no    | no   | no   | no   |
| 143    | User-Acct-Time               | no   | no   | no   | no     | no    | no   | no   | no   |
| 144    | Assign-IP-Client             | no   | no   | no   | no     | no    | no   | no   | no   |
| 145    | Assign-IP-Server             | no   | no   | no   | no     | no    | no   | no   | no   |
| 146    | Assign-IP-Global-Pool        | no   | no   | no   | no     | no    | no   | no   | no   |
| 147    | DHCP-Reply                   | no   | no   | no   | no     | no    | no   | no   | no   |
| 148    | DHCP-Pool-Number             | no   | no   | no   | no     | no    | no   | no   | no   |
| 149    | Expect-Callback              | no   | no   | no   | no     | no    | no   | no   | no   |
| 150    | Event-Type                   | no   | no   | no   | no     | no    | no   | no   | no   |
| 151    | Session-Svr-Key              | no   | no   | no   | yes    | no    | no   | yes  | yes  |
| 152    | Multicast-Rate-Limit         | no   | no   | no   | yes    | no    | no   | yes  | yes  |
| 153    | IF-Netmask                   | no   | no   | no   | no     | no    | no   | no   | no   |

**Table 33** Supported Vendor-Proprietary RADIUS Attributes (continued)

| Number | Vendor-Proprietary Attribute | 11.1 | 11.2 | 11.3 | 11.3AA | 11.3T | 12.0 | 12.1 | 12.2 |
|--------|------------------------------|------|------|------|--------|-------|------|------|------|
| 154    | Remote-Addr                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 155    | Multicast-Client             | no   | no   | no   | yes    | no    | no   | yes  | yes  |
| 156    | FR-Circuit-Name              | no   | no   | no   | no     | no    | no   | no   | no   |
| 157    | FR-LinkUp                    | no   | no   | no   | no     | no    | no   | no   | no   |
| 158    | FR-Nailed-Grp                | no   | no   | no   | no     | no    | no   | no   | no   |
| 159    | FR-Type                      | no   | no   | no   | no     | no    | no   | no   | no   |
| 160    | FR-Link-Mgt                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 161    | FR-N391                      | no   | no   | no   | no     | no    | no   | no   | no   |
| 162    | FR-DCE-N392                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 163    | FR-DTE-N392                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 164    | FR-DCE-N393                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 165    | FR-DTE-N393                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 166    | FR-T391                      | no   | no   | no   | no     | no    | no   | no   | no   |
| 167    | FR-T392                      | no   | no   | no   | no     | no    | no   | no   | no   |
| 168    | Bridge-Address               | no   | no   | no   | no     | no    | no   | no   | no   |
| 169    | TS-Idle-Limit                | no   | no   | no   | no     | no    | no   | no   | no   |
| 170    | TS-Idle-Mode                 | no   | no   | no   | no     | no    | no   | no   | no   |
| 171    | DBA-Monitor                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 172    | Base-Channel-Count           | no   | no   | no   | no     | no    | no   | no   | no   |
| 173    | Minimum-Channels             | no   | no   | no   | no     | no    | no   | no   | no   |
| 174    | IPX-Route                    | no   | no   | no   | no     | no    | no   | no   | no   |
| 175    | FT1-Caller                   | no   | no   | no   | no     | no    | no   | no   | no   |
| 176    | Backup                       | no   | no   | no   | no     | no    | no   | no   | no   |
| 177    | Call-Type                    | no   | no   | no   | no     | no    | no   | no   | no   |
| 178    | Group                        | no   | no   | no   | no     | no    | no   | no   | no   |
| 179    | FR-DLCI                      | no   | no   | no   | no     | no    | no   | no   | no   |
| 180    | FR-Profile-Name              | no   | no   | no   | no     | no    | no   | no   | no   |
| 181    | Ara-PW                       | no   | no   | no   | no     | no    | no   | no   | no   |
| 182    | IPX-Node-Addr                | no   | no   | no   | no     | no    | no   | no   | no   |
| 183    | Home-Agent-IP-Addr           | no   | no   | no   | no     | no    | no   | no   | no   |
| 184    | Home-Agent-Password          | no   | no   | no   | no     | no    | no   | no   | no   |
| 185    | Home-Network-Name            | no   | no   | no   | no     | no    | no   | no   | no   |
| 186    | Home-Agent-UDP-Port          | no   | no   | no   | no     | no    | no   | no   | no   |
| 187    | Multilink-ID                 | no   | no   | no   | yes    | yes   | yes  | yes  | yes  |
| 188    | Num-In-Multilink             | no   | no   | no   | yes    | yes   | yes  | yes  | yes  |

**Table 33** Supported Vendor-Proprietary RADIUS Attributes (continued)

| Number | Vendor-Proprietary Attribute | 11.1 | 11.2 | 11.3 | 11.3AA | 11.3T | 12.0 | 12.1 | 12.2 |
|--------|------------------------------|------|------|------|--------|-------|------|------|------|
| 189    | First-Dest                   | no   | no   | no   | no     | no    | no   | no   | no   |
| 190    | Pre-Input-Octets             | no   | no   | no   | yes    | yes   | yes  | yes  | yes  |
| 191    | Pre-Output-Octets            | no   | no   | no   | yes    | yes   | yes  | yes  | yes  |
| 192    | Pre-Input-Packets            | no   | no   | no   | yes    | yes   | yes  | yes  | yes  |
| 193    | Pre-Output-Packets           | no   | no   | no   | yes    | yes   | yes  | yes  | yes  |
| 194    | Maximum-Time                 | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 195    | Disconnect-Cause             | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 196    | Connect-Progress             | no   | no   | no   | no     | no    | no   | yes  | yes  |
| 197    | Data-Rate                    | no   | no   | no   | no     | yes   | yes  | yes  | yes  |
| 198    | PreSession-Time              | no   | no   | no   | yes    | yes   | yes  | yes  | yes  |
| 199    | Token-Idle                   | no   | no   | no   | no     | no    | no   | no   | no   |
| 201    | Require-Auth                 | no   | no   | no   | no     | no    | no   | no   | no   |
| 202    | Number-Sessions              | no   | no   | no   | no     | no    | no   | no   | no   |
| 203    | Authen-Alias                 | no   | no   | no   | no     | no    | no   | no   | no   |
| 204    | Token-Expiry                 | no   | no   | no   | no     | no    | no   | no   | no   |
| 205    | Menu-Selector                | no   | no   | no   | no     | no    | no   | no   | no   |
| 206    | Menu-Item                    | no   | no   | no   | no     | no    | no   | no   | no   |
| 207    | PW-Warntime                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 208    | PW-Lifetime                  | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 209    | IP-Direct                    | no   | no   | no   | no     | yes   | yes  | yes  | yes  |
| 210    | PPP-VJ-Slot-Comp             | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 211    | PPP-VJ-1172                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 212    | PPP-Async-Map                | no   | no   | no   | no     | no    | no   | no   | no   |
| 213    | Third-Prompt                 | no   | no   | no   | no     | no    | no   | no   | no   |
| 214    | Send-Secret                  | no   | no   | no   | no     | no    | no   | yes  | yes  |
| 215    | Receive-Secret               | no   | no   | no   | no     | no    | no   | no   | no   |
| 216    | IPX-Peer-Mode                | no   | no   | no   | no     | no    | no   | no   | no   |
| 217    | IP-Pool-Definition           | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 218    | Assign-IP-Pool               | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 219    | FR-Direct                    | no   | no   | no   | no     | no    | no   | no   | no   |
| 220    | FR-Direct-Profile            | no   | no   | no   | no     | no    | no   | no   | no   |
| 221    | FR-Direct-DLCI               | no   | no   | no   | no     | no    | no   | no   | no   |
| 222    | Handle-IPX                   | no   | no   | no   | no     | no    | no   | no   | no   |
| 223    | Netware-Timeout              | no   | no   | no   | no     | no    | no   | no   | no   |
| 224    | IPX-Alias                    | no   | no   | no   | no     | no    | no   | no   | no   |



**Table 33** Supported Vendor-Proprietary RADIUS Attributes (continued)

| Number | Vendor-Proprietary Attribute | 11.1 | 11.2 | 11.3 | 11.3AA | 11.3T | 12.0 | 12.1 | 12.2 |
|--------|------------------------------|------|------|------|--------|-------|------|------|------|
| 225    | Metric                       | no   | no   | no   | no     | no    | no   | no   | no   |
| 226    | PRI-Number-Type              | no   | no   | no   | no     | no    | no   | no   | no   |
| 227    | Dial-Number                  | no   | no   | no   | no     | no    | no   | yes  | yes  |
| 228    | Route-IP                     | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 229    | Route-IPX                    | no   | no   | no   | no     | no    | no   | no   | no   |
| 230    | Bridge                       | no   | no   | no   | no     | no    | no   | no   | no   |
| 231    | Send-Auth                    | no   | no   | no   | no     | no    | no   | yes  | yes  |
| 232    | Send-Passwd                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 233    | Link-Compression             | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 234    | Target-Util                  | no   | no   | no   | yes    | no    | yes  | yes  | yes  |
| 235    | Maximum-Channels             | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 236    | Inc-Channel-Count            | no   | no   | no   | no     | no    | no   | no   | no   |
| 237    | Dec-Channel-Count            | no   | no   | no   | no     | no    | no   | no   | no   |
| 238    | Seconds-of-History           | no   | no   | no   | no     | no    | no   | no   | no   |
| 239    | History-Weigh-Type           | no   | no   | no   | no     | no    | no   | no   | no   |
| 240    | Add-Seconds                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 241    | Remove-Seconds               | no   | no   | no   | no     | no    | no   | no   | no   |
| 242    | Data-Filter                  | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 243    | Call-Filter                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 244    | Idle-Limit                   | no   | no   | yes  | yes    | yes   | yes  | yes  | yes  |
| 245    | Preempt-Limit                | no   | no   | no   | no     | no    | no   | no   | no   |
| 246    | Callback                     | no   | no   | no   | no     | no    | no   | no   | no   |
| 247    | Data-Svc                     | no   | no   | no   | no     | no    | no   | yes  | yes  |
| 248    | Force-56                     | no   | no   | no   | no     | no    | no   | yes  | yes  |
| 249    | Billing Number               | no   | no   | no   | no     | no    | no   | no   | no   |
| 250    | Call-By-Call                 | no   | no   | no   | no     | no    | no   | no   | no   |
| 251    | Transit-Number               | no   | no   | no   | no     | no    | no   | no   | no   |
| 252    | Host-Info                    | no   | no   | no   | no     | no    | no   | no   | no   |
| 253    | PPP-Address                  | no   | no   | no   | no     | no    | no   | no   | no   |
| 254    | MPP-Idle-Percent             | no   | no   | no   | no     | no    | no   | no   | no   |
| 255    | Xmit-Rate                    | no   | no   | no   | yes    | yes   | yes  | yes  | yes  |

## Comprehensive List of Vendor-Proprietary RADIUS Attribute Descriptions

Table 34 lists and describes the known vendor-proprietary RADIUS attributes:

**Table 34 Vendor-Proprietary RADIUS Attributes**

| Number | Vendor-Proprietary Attribute | Description                                                                                                                                                          |
|--------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 17     | Change-Password              | Specifies a request to change the password of a user.                                                                                                                |
| 21     | Password-Expiration          | Specifies an expiration date for a user's password in the user's file entry.                                                                                         |
| 68     | Tunnel-ID                    | (Ascend 5) Specifies the string assigned by RADIUS for each session using CLID or DNIS tunneling. When accounting is implemented, this value is used for accounting. |
| 108    | My-Endpoint-Disc-Alias       | (Ascend 5) No description available.                                                                                                                                 |
| 109    | My-Name-Alias                | (Ascend 5) No description available.                                                                                                                                 |
| 110    | Remote-FW                    | (Ascend 5) No description available.                                                                                                                                 |
| 111    | Multicast-GLeave-Delay       | (Ascend 5) No description available.                                                                                                                                 |
| 112    | CBCP-Enable                  | (Ascend 5) No description available.                                                                                                                                 |
| 113    | CBCP-Mode                    | (Ascend 5) No description available.                                                                                                                                 |
| 114    | CBCP-Delay                   | (Ascend 5) No description available.                                                                                                                                 |
| 115    | CBCP-Trunk-Group             | (Ascend 5) No description available.                                                                                                                                 |
| 116    | Appletalk-Route              | (Ascend 5) No description available.                                                                                                                                 |
| 117    | Appletalk-Peer-Mode          | (Ascend 5) No description available.                                                                                                                                 |
| 118    | Route-Appletalk              | (Ascend 5) No description available.                                                                                                                                 |
| 119    | FCP-Parameter                | (Ascend 5) No description available.                                                                                                                                 |
| 120    | Modem-PortNo                 | (Ascend 5) No description available.                                                                                                                                 |
| 121    | Modem-SlotNo                 | (Ascend 5) No description available.                                                                                                                                 |
| 122    | Modem-ShelfNo                | (Ascend 5) No description available.                                                                                                                                 |
| 123    | Call-Attempt-Limit           | (Ascend 5) No description available.                                                                                                                                 |
| 124    | Call-Block-Duration          | (Ascend 5) No description available.                                                                                                                                 |
| 125    | Maximum-Call-Duration        | (Ascend 5) No description available.                                                                                                                                 |
| 126    | Router-Preference            | (Ascend 5) No description available.                                                                                                                                 |
| 127    | Tunneling-Protocol           | (Ascend 5) No description available.                                                                                                                                 |
| 128    | Shared-Profile-Enable        | (Ascend 5) No description available.                                                                                                                                 |
| 129    | Primary-Home-Agent           | (Ascend 5) No description available.                                                                                                                                 |
| 130    | Secondary-Home-Agent         | (Ascend 5) No description available.                                                                                                                                 |
| 131    | Dialout-Allowed              | (Ascend 5) No description available.                                                                                                                                 |
| 133    | BACP-Enable                  | (Ascend 5) No description available.                                                                                                                                 |
| 134    | DHCP-Maximum-Leases          | (Ascend 5) No description available.                                                                                                                                 |

**Table 34 Vendor-Proprietary RADIUS Attributes (continued)**

| Number | Vendor-Proprietary Attribute | Description                                                                                                                              |
|--------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 135    | Primary-DNS-Server           | Identifies a primary DNS server that can be requested by Microsoft PPP clients from the network access server during IPCP negotiation.   |
| 136    | Secondary-DNS-Server         | Identifies a secondary DNS server that can be requested by Microsoft PPP clients from the network access server during IPCP negotiation. |
| 137    | Client-Assign-DNS            | No description available.                                                                                                                |
| 138    | User-Acct-Type               | No description available.                                                                                                                |
| 139    | User-Acct-Host               | No description available.                                                                                                                |
| 140    | User-Acct-Port               | No description available.                                                                                                                |
| 141    | User-Acct-Key                | No description available.                                                                                                                |
| 142    | User-Acct-Base               | No description available.                                                                                                                |
| 143    | User-Acct-Time               | No description available.                                                                                                                |
| 144    | Assign-IP-Client             | No description available.                                                                                                                |
| 145    | Assign-IP-Server             | No description available.                                                                                                                |
| 146    | Assign-IP-Global-Pool        | No description available.                                                                                                                |
| 147    | DHCP-Reply                   | No description available.                                                                                                                |
| 148    | DHCP-Pool-Number             | No description available.                                                                                                                |
| 149    | Expect-Callback              | No description available.                                                                                                                |
| 150    | Event-Type                   | No description available.                                                                                                                |
| 151    | Session-Svr-Key              | No description available.                                                                                                                |
| 152    | Multicast-Rate-Limit         | No description available.                                                                                                                |
| 153    | IF-Netmask                   | No description available.                                                                                                                |
| 154    | Remote-Addr                  | No description available.                                                                                                                |
| 155    | Multicast-Client             | No description available.                                                                                                                |
| 156    | FR-Circuit-Name              | No description available.                                                                                                                |
| 157    | FR-LinkUp                    | No description available.                                                                                                                |
| 158    | FR-Nailed-Grp                | No description available.                                                                                                                |
| 159    | FR-Type                      | No description available.                                                                                                                |
| 160    | FR-Link-Mgt                  | No description available.                                                                                                                |
| 161    | FR-N391                      | No description available.                                                                                                                |
| 162    | FR-DCE-N392                  | No description available.                                                                                                                |
| 163    | FR-DTE-N392                  | No description available.                                                                                                                |
| 164    | FR-DCE-N393                  | No description available.                                                                                                                |
| 165    | FR-DTE-N393                  | No description available.                                                                                                                |
| 166    | FR-T391                      | No description available.                                                                                                                |
| 167    | FR-T392                      | No description available.                                                                                                                |

**Table 34** *Vendor-Proprietary RADIUS Attributes (continued)*

| Number | Vendor-Proprietary Attribute | Description                                                                                                                                                                                                                                                                                                             |
|--------|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 168    | Bridge-Address               | No description available.                                                                                                                                                                                                                                                                                               |
| 169    | TS-Idle-Limit                | No description available.                                                                                                                                                                                                                                                                                               |
| 170    | TS-Idle-Mode                 | No description available.                                                                                                                                                                                                                                                                                               |
| 171    | DBA-Monitor                  | No description available.                                                                                                                                                                                                                                                                                               |
| 172    | Base-Channel-Count           | No description available.                                                                                                                                                                                                                                                                                               |
| 173    | Minimum-Channels             | No description available.                                                                                                                                                                                                                                                                                               |
| 174    | IPX-Route                    | No description available.                                                                                                                                                                                                                                                                                               |
| 175    | FT1-Caller                   | No description available.                                                                                                                                                                                                                                                                                               |
| 176    | Backup                       | No description available.                                                                                                                                                                                                                                                                                               |
| 177    | Call-Type                    | No description available.                                                                                                                                                                                                                                                                                               |
| 178    | Group                        | No description available.                                                                                                                                                                                                                                                                                               |
| 179    | FR-DLCI                      | No description available.                                                                                                                                                                                                                                                                                               |
| 180    | FR-Profile-Name              | No description available.                                                                                                                                                                                                                                                                                               |
| 181    | Ara-PW                       | No description available.                                                                                                                                                                                                                                                                                               |
| 182    | IPX-Node-Addr                | No description available.                                                                                                                                                                                                                                                                                               |
| 183    | Home-Agent-IP-Addr           | Indicates the home agent's IP address (in dotted decimal format) when using Ascend Tunnel Management Protocol (ATMP).                                                                                                                                                                                                   |
| 184    | Home-Agent-Password          | With ATMP, specifies the password that the foreign agent uses to authenticate itself.                                                                                                                                                                                                                                   |
| 185    | Home-Network-Name            | With ATMP, indicates the name of the connection profile to which the home agent sends all packets.                                                                                                                                                                                                                      |
| 186    | Home-Agent-UDP-Port          | Indicates the UDP port number the foreign agent uses to send ATMP messages to the home agent.                                                                                                                                                                                                                           |
| 187    | Multilink-ID                 | Reports the identification number of the multilink bundle when the session closes. This attribute applies to sessions that are part of a multilink bundle. The Multilink-ID attribute is sent in authentication-response packets.                                                                                       |
| 188    | Num-In-Multilink             | Reports the number of sessions remaining in a multilink bundle when the session reported in an accounting-stop packet closes. This attribute applies to sessions that are part of a multilink bundle. The Num-In-Multilink attribute is sent in authentication-response packets and in some accounting-request packets. |
| 189    | First-Dest                   | Records the destination IP address of the first packet received after authentication.                                                                                                                                                                                                                                   |
| 190    | Pre-Input-Octets             | Records the number of input octets before authentication. The Pre-Input-Octets attribute is sent in accounting-stop records.                                                                                                                                                                                            |
| 191    | Pre-Output-Octets            | Records the number of output octets before authentication. The Pre-Output-Octets attribute is sent in accounting-stop records.                                                                                                                                                                                          |

**Table 34 Vendor-Proprietary RADIUS Attributes (continued)**

| Number | Vendor-Proprietary Attribute | Description                                                                                                                                                                                                                                                                                                                                                                                          |
|--------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 192    | Pre-Input-Packets            | Records the number of input packets before authentication. The Pre-Input-Packets attribute is sent in accounting-stop records.                                                                                                                                                                                                                                                                       |
| 193    | Pre-Output-Packets           | Records the number of output packets before authentication. The Pre-Output-Packets attribute is sent in accounting-stop records.                                                                                                                                                                                                                                                                     |
| 194    | Maximum-Time                 | Specifies the maximum length of time (in seconds) allowed for any session. After the session reaches the time limit, its connection is dropped.                                                                                                                                                                                                                                                      |
| 195    | Disconnect-Cause             | Specifies the reason a connection was taken offline. The Disconnect-Cause attribute is sent in accounting-stop records. This attribute also causes stop records to be generated without first generating start records if disconnection occurs before authentication is performed. For more information, refer to the table of <a href="#">Disconnect-Cause Attribute Values</a> and their meanings. |
| 196    | Connect-Progress             | Indicates the connection state before the connection is disconnected.                                                                                                                                                                                                                                                                                                                                |
| 197    | Data-Rate                    | Specifies the average number of bits per second over the course of the connection's lifetime. The Data-Rate attribute is sent in accounting-stop records.                                                                                                                                                                                                                                            |
| 198    | PreSession-Time              | Specifies the length of time, in seconds, from when a call first connects to when it completes authentication. The PreSession-Time attribute is sent in accounting-stop records.                                                                                                                                                                                                                     |
| 199    | Token-Idle                   | Indicates the maximum amount of time (in minutes) a cached token can remain alive between authentications.                                                                                                                                                                                                                                                                                           |
| 201    | Require-Auth                 | Defines whether additional authentication is required for class that has been CLID authenticated.                                                                                                                                                                                                                                                                                                    |
| 202    | Number-Sessions              | Specifies the number of active sessions (per class) reported to the RADIUS accounting server.                                                                                                                                                                                                                                                                                                        |
| 203    | Authen-Alias                 | Defines the RADIUS server's login name during PPP authentication.                                                                                                                                                                                                                                                                                                                                    |
| 204    | Token-Expiry                 | Defines the lifetime of a cached token.                                                                                                                                                                                                                                                                                                                                                              |
| 205    | Menu-Selector                | Defines a string to be used to cue a user to input data.                                                                                                                                                                                                                                                                                                                                             |
| 206    | Menu-Item                    | Specifies a single menu-item for a user-profile. Up to 20 menu items can be assigned per profile.                                                                                                                                                                                                                                                                                                    |
| 207    | PW-Warntime                  | (Ascend 5) No description available.                                                                                                                                                                                                                                                                                                                                                                 |
| 208    | PW-Lifetime                  | Enables you to specify on a per-user basis the number of days that a password is valid.                                                                                                                                                                                                                                                                                                              |

**Table 34** Vendor-Proprietary RADIUS Attributes (continued)

| Number | Vendor-Proprietary Attribute | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 209    | IP-Direct                    | <p>When you include this attribute in a user's file entry, a framed route is installed to the routing and bridging tables.</p> <p><b>Note</b> Packet routing is dependent upon the entire table, not just this newly installed entry. The inclusion of this attribute does not guarantee that all packets should be sent to the specified IP address; thus, this attribute is not fully supported.</p> <p>These attribute limitations occur because the Cisco router cannot bypass all internal routing and bridging tables and send packets to a specified IP address.</p> |
| 210    | PPP-VJ-Slot-Comp             | Instructs the Cisco router not to use slot compression when sending VJ-compressed packets over a PPP link.                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 211    | PPP-VJ-1172                  | Instructs PPP to use the 0x0037 value for VJ compression.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 212    | PPP-Async-Map                | Gives the Cisco router the asynchronous control character map for the PPP session. The specified control characters are passed through the PPP link as data and used by applications running over the link.                                                                                                                                                                                                                                                                                                                                                                 |
| 213    | Third-Prompt                 | Defines a third prompt (after username and password) for additional user input.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 214    | Send-Secret                  | Enables an encrypted password to be used in place of a regular password in outdial profiles.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 215    | Receive-Secret               | Enables an encrypted password to be verified by the RADIUS server.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 216    | IPX-Peer-Mode                | (Ascend 5) No description available.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 217    | IP-Pool-Definition           | Defines a pool of addresses using the following format: X a.b.c Z; where X is the pool index number, a.b.c is the pool's starting IP address, and Z is the number of IP addresses in the pool. For example, 3 10.0.0.1 5 allocates 10.0.0.1 through 10.0.0.5 for dynamic assignment.                                                                                                                                                                                                                                                                                        |
| 218    | Assign-IP-Pool               | Tells the router to assign the user and IP address from the IP pool.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 219    | FR-Direct                    | Defines whether the connection profile operates in Frame Relay redirect mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 220    | FR-Direct-Profile            | Defines the name of the Frame Relay profile carrying this connection to the Frame Relay switch.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 221    | FR-Direct-DLCI               | Indicates the DLCI carrying this connection to the Frame Relay switch.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 222    | Handle-IPX                   | Indicates how NCP watchdog requests will be handled.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 223    | Netware-Timeout              | Defines, in minutes, how long the RADIUS server responds to NCP watchdog packets.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 224    | IPX-Alias                    | Allows you to define an alias for IPX routers requiring numbered interfaces.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

**Table 34 Vendor-Proprietary RADIUS Attributes (continued)**

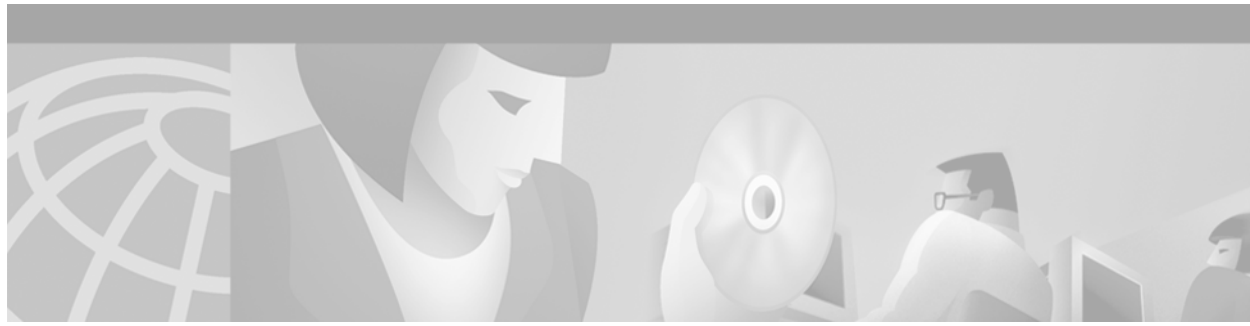
| Number | Vendor-Proprietary Attribute | Description                                                                                                                                                                                                                                                                                     |
|--------|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 225    | Metric                       | No description available.                                                                                                                                                                                                                                                                       |
| 226    | PRI-Number-Type              | No description available.                                                                                                                                                                                                                                                                       |
| 227    | Dial-Number                  | Defines the number to dial.                                                                                                                                                                                                                                                                     |
| 228    | Route-IP                     | Indicates whether IP routing is allowed for the user's file entry.                                                                                                                                                                                                                              |
| 229    | Route-IPX                    | Allows you to enable IPX routing.                                                                                                                                                                                                                                                               |
| 230    | Bridge                       | No description available.                                                                                                                                                                                                                                                                       |
| 231    | Send-Auth                    | Defines the protocol to use (PAP or CHAP) for username-password authentication following CLID authentication.                                                                                                                                                                                   |
| 232    | Send-Passwd                  | Enables the RADIUS server to specify the password that is sent to the remote end of a connection on outgoing calls.                                                                                                                                                                             |
| 233    | Link-Compression             | <p>Defines whether to turn on or turn off "stac" compression over a PPP link.</p> <p>Link compression is defined as a numeric value as follows:</p> <ul style="list-style-type: none"> <li>• 0: None</li> <li>• 1: Stac</li> <li>• 2: Stac-Draft-9</li> <li>• 3: MS-Stac</li> </ul>             |
| 234    | Target-Util                  | Specifies the load-threshold percentage value for bringing up an additional channel when PPP multilink is defined.                                                                                                                                                                              |
| 235    | Maximum-Channels             | Specifies allowed/allocatable maximum number of channels.                                                                                                                                                                                                                                       |
| 236    | Inc-Channel-Count            | No description available.                                                                                                                                                                                                                                                                       |
| 237    | Dec-Channel-Count            | No description available.                                                                                                                                                                                                                                                                       |
| 238    | Seconds-of-History           | No description available.                                                                                                                                                                                                                                                                       |
| 239    | History-Weigh-Type           | No description available.                                                                                                                                                                                                                                                                       |
| 240    | Add-Seconds                  | No description available.                                                                                                                                                                                                                                                                       |
| 241    | Remove-Seconds               | No description available.                                                                                                                                                                                                                                                                       |
| 242    | Data-Filter                  | Defines per-user IP data filters. These filters are retrieved only when a call is placed using a RADIUS outgoing profile or answered using a RADIUS incoming profile. Filter entries are applied on a first-match basis; therefore, the order in which filter entries are entered is important. |
| 243    | Call-Filter                  | Defines per-user IP data filters. On a Cisco router, this attribute is identical to the Data-Filter attribute.                                                                                                                                                                                  |
| 244    | Idle-Limit                   | Specifies the maximum time (in seconds) that any session can be idle. When the session reaches the idle time limit, its connection is dropped.                                                                                                                                                  |
| 245    | Preempt-Limit                | No description available.                                                                                                                                                                                                                                                                       |

**Table 34** *Vendor-Proprietary RADIUS Attributes (continued)*

| Number | Vendor-Proprietary Attribute | Description                                                                                                                      |
|--------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| 246    | Callback                     | Allows you to enable or disable callback.                                                                                        |
| 247    | Data-Svc                     | No description available.                                                                                                        |
| 248    | Force-56                     | Determines whether the network access server uses only the 56 K portion of a channel, even when all 64 K appear to be available. |
| 249    | Billing Number               | No description available.                                                                                                        |
| 250    | Call-By-Call                 | No description available.                                                                                                        |
| 251    | Transit-Number               | No description available.                                                                                                        |
| 252    | Host-Info                    | No description available.                                                                                                        |
| 253    | PPP-Address                  | Indicates the IP address reported to the calling unit during PPP IPCP negotiations.                                              |
| 254    | MPP-Idle-Percent             | No description available.                                                                                                        |
| 255    | Xmit-Rate                    | (Ascend 5) No description available.                                                                                             |

For more information on vendor-proprietary RADIUS attributes, refer to the section “[Configuring Router for Vendor-Proprietary RADIUS Server Communication](#)” in the chapter “[Configuring RADIUS](#).”





## RADIUS Vendor-Specific Attributes (VSA)

The Internet Engineering Task Force (IETF) draft standard specifies a method for communicating vendor-specific information between the network access server and the RADIUS server by using the vendor-specific attribute (attribute 26). Attribute 26 encapsulates vendor specific attributes, thereby, allowing vendors to support their own extended attributes otherwise not suitable for general use.

The Cisco RADIUS implementation supports one vendor-specific option using the format recommended in the specification. Cisco's vendor-ID is 9, and the supported option has vendor-type 1, which is named "cisco-avpair." The value is a string of the following format:

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

"Protocol" is a value of the Cisco "protocol" attribute for a particular type of authorization; protocols that can be used include IP, IPX, VPDN, VOIP, SHELL, RSVP, SIP, AIRNET, OUTBOUND. "Attribute" and "value" are an appropriate attribute-value (AV) pair defined in the Cisco TACACS+ specification, and "sep" is "=" for mandatory attributes and "\*" for optional attributes. This allows the full set of features available for TACACS+ authorization to also be used for RADIUS.

For example, the following AV pair causes Cisco's "multiple named ip address pools" feature to be activated during IP authorization (during PPP's IPCP address assignment):

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

If you insert an "\*", the AV pair "ip:addr-pool=first" becomes optional. Note that any AV pair can be made optional.

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

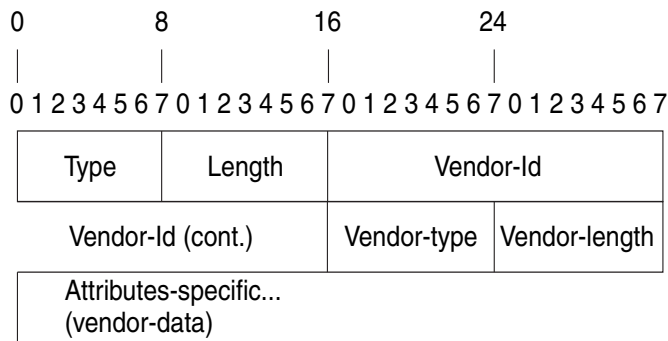
The following example shows how to cause a user logging in from a network access server to have immediate access to EXEC commands:

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

Attribute 26 contains the following three elements:

- Type
- Length
- String (also known as data)
  - Vendor-Id
  - Vendor-Type
  - Vendor-Length
  - Vendor-Data

Figure 44 shows the packet format for a VSA encapsulated "behind" attribute 26.

**Figure 44 VSA Encapsulated Behind Attribute 26**

51325

**Note**

It is up to the vendor to specify the format of their VSA. The Attribute-Specific field (also known as Vendor-Data) is dependent on the vendor's definition of that attribute.

[Table 36](#) lists supported vendor-specific RADIUS attributes (IETF attribute 26). [Table 35](#) describes significant fields listed in the [Table 36](#).

**Table 35 Vendor-Specific Attributes Table Field Descriptions**

| Field                         | Description                                                                                                                                                    |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Number                        | All attributes listed in the following table are extensions of IETF attribute 26.                                                                              |
| Vendor-Specific Command Codes | A defined code used to identify a particular vendor. Code 9 defines Cisco VSAs, 311 defines Microsoft VSAs, and 529 defines Ascend VSAs.                       |
| Sub-Type Number               | The attribute ID number. This number is much like the ID numbers of IETF attributes, except it is a “second layer” ID number encapsulated behind attribute 26. |
| Attribute                     | The ASCII string name of the attribute.                                                                                                                        |
| Description                   | Description of the attribute.                                                                                                                                  |

**Table 36 Vendor-Specific RADIUS IETF Attributes**

| Number                    | Vendor-Specific Company Code | Sub-Type Number | Attribute                 | Description                                                                                                                                                                                            |
|---------------------------|------------------------------|-----------------|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>MS-CHAP Attributes</b> |                              |                 |                           |                                                                                                                                                                                                        |
| 26                        | 311                          | 1               | MSCHAP-Response           | Contains the response value provided by a PPP MS-CHAP user in response to the challenge. It is only used in Access-Request packets. This attribute is identical to the PPP CHAP Identifier. (RFC 2548) |
| 26                        | 311                          | 11              | MSCHAP-Challenge          | Contains the challenge sent by a network access server to an MS-CHAP user. It can be used in both Access-Request and Access-Challenge packets. (RFC 2548)                                              |
| <b>VPDN Attributes</b>    |                              |                 |                           |                                                                                                                                                                                                        |
| 26                        | 9                            | 1               | l2tp-cm-local-window-size | Specifies the maximum receive window size for L2TP control messages. This value is advertised to the peer during tunnel establishment.                                                                 |

**Table 36** Vendor-Specific RADIUS IETF Attributes (continued)

| Number                                  | Vendor-Specific Company Code | Sub-Type Number | Attribute              | Description                                                                                                                                                                                                                                                                                                  |
|-----------------------------------------|------------------------------|-----------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 26                                      | 9                            | 1               | l2tp-drop-out-of-order | Respects sequence numbers on data packets by dropping those that are received out of order. This does not ensure that sequence numbers will be sent on data packets, just how to handle them if they are received.                                                                                           |
| 26                                      | 9                            | 1               | l2tp-hello-interval    | Specifies the number of seconds for the hello keepalive interval. Hello packets are sent when no data has been sent on a tunnel for the number of seconds configured here.                                                                                                                                   |
| 26                                      | 9                            | 1               | l2tp-hidden-avp        | When enabled, sensitive AVPs in L2TP control messages are scrambled or hidden.                                                                                                                                                                                                                               |
| 26                                      | 9                            | 1               | l2tp-nosession-timeout | Specifies the number of seconds that a tunnel will stay active with no sessions before timing out and shutting down.                                                                                                                                                                                         |
| 26                                      | 9                            | 1               | tunnel-tos-reflect     | Copies the IP ToS field from the IP header of each payload packet to the IP header of the tunnel packet for packets entering the tunnel at the LNS.                                                                                                                                                          |
| 26                                      | 9                            | 1               | l2tp-tunnel-authen     | If this attribute is set, it performs L2TP tunnel authentication.                                                                                                                                                                                                                                            |
| 26                                      | 9                            | 1               | l2tp-tunnel-password   | Shared secret used for L2TP tunnel authentication and AVP hiding.                                                                                                                                                                                                                                            |
| 26                                      | 9                            | 1               | l2tp-udp-checksum      | This is an authorization attribute and defines whether L2TP should perform UDP checksums for data packets. Valid values are “yes” and “no.” The default is no.                                                                                                                                               |
| <b>Store and Forward Fax Attributes</b> |                              |                 |                        |                                                                                                                                                                                                                                                                                                              |
| 26                                      | 9                            | 3               | Fax-Account-Id-Origin  | Indicates the account ID origin as defined by system administrator for the <b>mmoip aaa receive-id</b> or the <b>mmoip aaa send-id</b> commands.                                                                                                                                                             |
| 26                                      | 9                            | 4               | Fax-Msg-Id=            | Indicates a unique fax message identification number assigned by Store and Forward Fax.                                                                                                                                                                                                                      |
| 26                                      | 9                            | 5               | Fax-Pages              | Indicates the number of pages transmitted or received during this fax session. This page count includes cover pages.                                                                                                                                                                                         |
| 26                                      | 9                            | 6               | Fax-Coverpage-Flag     | Indicates whether or not a cover page was generated by the off-ramp gateway for this fax session. True indicates that a cover page was generated; false means that a cover page was not generated.                                                                                                           |
| 26                                      | 9                            | 7               | Fax-Modem-Time         | Indicates the amount of time in seconds the modem sent fax data (x) and the amount of time in seconds of the total fax session (y), which includes both fax-mail and PSTN time, in the form x/y. For example, 10/15 means that the transfer time took 10 seconds, and the total fax session took 15 seconds. |

**Table 36** Vendor-Specific RADIUS IETF Attributes (continued)

| Number                 | Vendor-Specific Company Code | Sub-Type Number | Attribute                                  | Description                                                                                                                                                                                                                                                                                 |
|------------------------|------------------------------|-----------------|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 26                     | 9                            | 8               | Fax-Connect-Speed                          | Indicates the modem speed at which this fax-mail was initially transmitted or received. Possible values are 1200, 4800, 9600, and 14400.                                                                                                                                                    |
| 26                     | 9                            | 9               | Fax-Recipient-Count                        | Indicates the number of recipients for this fax transmission. Until e-mail servers support Session mode, the number should be 1.                                                                                                                                                            |
| 26                     | 9                            | 10              | Fax-Process-Abort-Flag                     | Indicates that the fax session was aborted or successful. True means that the session was aborted; false means that the session was successful.                                                                                                                                             |
| 26                     | 9                            | 11              | Fax-Dsn-Address                            | Indicates the address to which DSNs will be sent.                                                                                                                                                                                                                                           |
| 26                     | 9                            | 12              | Fax-Dsn-Flag                               | Indicates whether or not DSN has been enabled. True indicates that DSN has been enabled; false means that DSN has not been enabled.                                                                                                                                                         |
| 26                     | 9                            | 13              | Fax-Mdn-Address                            | Indicates the address to which MDNs will be sent.                                                                                                                                                                                                                                           |
| 26                     | 9                            | 14              | Fax-Mdn-Flag                               | Indicates whether or not message delivery notification (MDN) has been enabled. True indicates that MDN had been enabled; false means that MDN had not been enabled.                                                                                                                         |
| 26                     | 9                            | 15              | Fax-Auth-Status                            | Indicates whether or not authentication for this fax session was successful. Possible values for this field are success, failed, bypassed, or unknown.                                                                                                                                      |
| 26                     | 9                            | 16              | Email-Server-Address                       | Indicates the IP address of the e-mail server handling the on-ramp fax-mail message.                                                                                                                                                                                                        |
| 26                     | 9                            | 17              | Email-Server-Ack-Flag                      | Indicates that the on-ramp gateway has received a positive acknowledgment from the e-mail server accepting the fax-mail message.                                                                                                                                                            |
| 26                     | 9                            | 18              | Gateway-Id                                 | Indicates the name of the gateway that processed the fax session. The name appears in the following format: hostname.domain-name.                                                                                                                                                           |
| 26                     | 9                            | 19              | Call-Type                                  | Describes the type of fax activity: fax receive or fax send.                                                                                                                                                                                                                                |
| 26                     | 9                            | 20              | Port-Used                                  | Indicates the slot/port number of the Cisco AS5300 used to either transmit or receive this fax-mail.                                                                                                                                                                                        |
| 26                     | 9                            | 21              | Abort-Cause                                | If the fax session aborts, indicates the system component that signaled the abort. Examples of system components that could trigger an abort are FAP (Fax Application Process), TIFF (the TIFF reader or the TIFF writer), fax-mail client, fax-mail server, ESMTP client, or ESMTP server. |
| <b>H323 Attributes</b> |                              |                 |                                            |                                                                                                                                                                                                                                                                                             |
| 26                     | 9                            | 23              | Remote-Gateway-ID<br>(h323-remote-address) | Indicates the IP address of the remote gateway.                                                                                                                                                                                                                                             |

**Table 36 Vendor-Specific RADIUS IETF Attributes (continued)**

| Number | Vendor-Specific Company Code | Sub-Type Number | Attribute                                   | Description                                                                                                                                 |
|--------|------------------------------|-----------------|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| 26     | 9                            | 24              | Connection-ID<br>(h323-conf-id)             | Identifies the conference ID.                                                                                                               |
| 26     | 9                            | 25              | Setup-Time<br>(h323-setup-time)             | Indicates the setup time for this connection in Coordinated Universal Time (UTC) formerly known as Greenwich Mean Time (GMT) and Zulu time. |
| 26     | 9                            | 26              | Call-Origin<br>(h323-call-origin)           | Indicates the origin of the call relative to the gateway. Possible values are originating and terminating (answer).                         |
| 26     | 9                            | 27              | Call-Type<br>(h323-call-type)               | Indicates call leg type. Possible values are <b>telephony</b> and <b>VoIP</b> .                                                             |
| 26     | 9                            | 28              | Connect-Time<br>(h323-connect-time)         | Indicates the connection time for this call leg in UTC.                                                                                     |
| 26     | 9                            | 29              | Disconnect-Time<br>(h323-disconnect-time)   | Indicates the time this call leg was disconnected in UTC.                                                                                   |
| 26     | 9                            | 30              | Disconnect-Cause<br>(h323-disconnect-caus)e | Specifies the reason a connection was taken offline per Q.931 specification.                                                                |
| 26     | 9                            | 31              | Voice-Quality<br>(h323-voice-quality)       | Specifies the impairment factor (ICPIF) affecting voice quality for a call.                                                                 |
| 26     | 9                            | 33              | Gateway-ID<br>(h323-gw-id)                  | Indicates the name of the underlying gateway.                                                                                               |

**Large Scale Dialout Attributes**

|    |   |   |                     |                                                                                                                                          |
|----|---|---|---------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 26 | 9 | 1 | callback-dialstring | Defines a dialing string to be used for callback.                                                                                        |
| 26 | 9 | 1 | data-service        | No description available.                                                                                                                |
| 26 | 9 | 1 | dial-number         | Defines the number to dial.                                                                                                              |
| 26 | 9 | 1 | force-56            | Determines whether the network access server uses only the 56 K portion of a channel, even when all 64 K appear to be available.         |
| 26 | 9 | 1 | map-class           | Allows the user profile to reference information configured in a map class of the same name on the network access server that dials out. |
| 26 | 9 | 1 | send-auth           | Defines the protocol to use (PAP or CHAP) for username-password authentication following CLID authentication.                            |

Table 36 Vendor-Specific RADIUS IETF Attributes (continued)

| Number                          | Vendor-Specific Company Code | Sub-Type Number | Attribute      | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------------------|------------------------------|-----------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 26                              | 9                            | 1               | send-name      | <p>PPP name authentication. To apply for PAP, do not configure the <b>ppp pap sent-name password</b> command on the interface. For PAP, “preauth:send-name” and “preauth:send-secret” will be used as the PAP username and PAP password for outbound authentication. For CHAP, “preauth:send-name” will be used not only for outbound authentication, but also for inbound authentication. For a CHAP inbound case, the NAS will use the name defined in “preauth:send-name” in the challenge packet to the caller box.</p> <p><b>Note</b> The send-name attribute has changed over time: Initially, it performed the functions now provided by both the send-name and remote-name attributes. Because the remote-name attribute has been added, the send-name attribute is restricted to its current behavior.</p> |
| 26                              | 9                            | 1               | send-secret    | <p>PPP password authentication. The vendor-specific attributes (VSAs) “preauth:send-name” and “preauth:send-secret” will be used as the PAP username and PAP password for outbound authentication. For a CHAP outbound case, both “preauth:send-name” and “preauth:send-secret” will be used in the response packet.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 26                              | 9                            | 1               | remote-name    | <p>Provides the name of the remote host for use in large-scale dial-out. Dialer checks that the large-scale dial-out remote name matches the authenticated name, to protect against accidental user RADIUS misconfiguration. (For example, dialing a valid phone number but connecting to the wrong router.)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Miscellaneous Attributes</b> |                              |                 |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 26                              | 9                            | 2               | Cisco-NAS-Port | <p>Specifies additional vendor specific attribute (VSA) information for NAS-Port accounting. To specify additional NAS-Port information in the form an Attribute-Value Pair (AVPair) string, use the <b>radius-server vsa send</b> global configuration command.</p> <p><b>Note</b> This VSA is typically used in Accounting, but may also be used in Authentication (Access-Request) packets.</p>                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 26                              | 9                            | 1               | min-links      | Sets the minimum number of links for MLP.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

**Table 36** Vendor-Specific RADIUS IETF Attributes (continued)

| Number | Vendor-Specific Company Code | Sub-Type Number | Attribute    | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------|------------------------------|-----------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 26     | 9                            | 1               | proxyacl#<n> | Allows users to configure the downloadable user profiles (dynamic ACLs) by using the authentication proxy feature so that users can have the configured authorization to permit traffic going through the configured interfaces.                                                                                                                                                                                                                                            |
| 26     | 9                            | 1               | spi          | Carries the authentication information needed by the home agent to authenticate a mobile node during registration. The information is in the same syntax as the <b>ip mobile secure host &lt;addr&gt;</b> configuration command. Basically it contains the rest of the configuration command that follows that string, verbatim. It provides the Security Parameter Index (SPI), key, authentication algorithm, authentication mode, and replay protection timestamp range. |

For more information on configuring your NAS to recognize and use VSAs, refer to the section [“Configuring Router to Use Vendor-Specific RADIUS Attributes”](#) of the chapter [“Configuring RADIUS.”](#)

## RADIUS Disconnect-Cause Attribute Values

Disconnect-cause attribute values specify the reason a connection was taken offline. The attribute values are sent in Accounting request packets. These values are sent at the end of a session, even if the session fails to be authenticated. If the session is not authenticated, the attribute can cause stop records to be generated without first generating start records.

[Table 37](#) lists the cause codes, values, and descriptions for the Disconnect-Cause (195) attribute.



### Note

The Disconnect-Cause is incremented by 1000 when it is used in RADIUS AVPairs; for example, disc-cause 4 becomes 1004.

**Table 37** Disconnect-Cause Attribute Values

| Cause Code | Value                       | Description                                          |
|------------|-----------------------------|------------------------------------------------------|
| 0          | No-Reason                   | No reason is given for the disconnect.               |
| 1          | No-Disconnect               | The event was not disconnected.                      |
| 2          | Unknown                     | Reason unknown.                                      |
| 3          | Call-Disconnect             | The call has been disconnected.                      |
| 4          | CLID-Authentication-Failure | Failure to authenticate number of the calling-party. |
| 9          | No-Modem-Available          | A modem is not available to connect the call.        |

**Table 37** Disconnect-Cause Attribute Values (continued)

| Cause Code | Value                      | Description                                                                                                                       |
|------------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| 10         | No-Carrier                 | No carrier detected.<br><b>Note</b> Codes 10, 11, and 12 can be sent if there is a disconnection during initial modem connection. |
| 11         | Lost-Carrier               | Loss of carrier.                                                                                                                  |
| 12         | No-Detected-Result-Codes   | Failure to detect modem result codes.                                                                                             |
| 20         | User-Ends-Session          | User terminates a session.<br><b>Note</b> Codes 20, 22, 23, 24, 25, 26, 27, and 28 apply to EXEC sessions.                        |
| 21         | Idle-Timeout               | Timeout waiting for user input.<br>Codes 21, 100, 101, 102, and 120 apply to all session types.                                   |
| 22         | Exit-Telnet-Session        | Disconnect due to exiting Telnet session.                                                                                         |
| 23         | No-Remote-IP-Addr          | Could not switch to SLIP/PPP; the remote end has no IP address.                                                                   |
| 24         | Exit-Raw-TCP               | Disconnect due to exiting raw TCP.                                                                                                |
| 25         | Password-Fail              | Bad passwords.                                                                                                                    |
| 26         | Raw-TCP-Disabled           | Raw TCP disabled.                                                                                                                 |
| 27         | Control-C-Detected         | Control-C detected.                                                                                                               |
| 28         | EXEC-Process-Destroyed     | EXEC process destroyed.                                                                                                           |
| 29         | Close-Virtual-Connection   | User closes a virtual connection.                                                                                                 |
| 30         | End-Virtual-Connection     | Virtual connected has ended.                                                                                                      |
| 31         | Exit-Rlogin                | User exists Rlogin.                                                                                                               |
| 32         | Invalid-Rlogin-Option      | Invalid Rlogin option selected.                                                                                                   |
| 33         | Insufficient-Resources     | Insufficient resources.                                                                                                           |
| 40         | Timeout-PPP-LCP            | PPP LCP negotiation timed out.<br><b>Note</b> Codes 40 through 49 apply to PPP sessions.                                          |
| 41         | Failed-PPP-LCP-Negotiation | PPP LCP negotiation failed.                                                                                                       |
| 42         | Failed-PPP-PAP-Auth-Fail   | PPP PAP authentication failed.                                                                                                    |
| 43         | Failed-PPP-CHAP-Auth       | PPP CHAP authentication failed.                                                                                                   |
| 44         | Failed-PPP-Remote-Auth     | PPP remote authentication failed.                                                                                                 |
| 45         | PPP-Remote-Terminate       | PPP received a Terminate Request from remote end.                                                                                 |
| 46         | PPP-Closed-Event           | Upper layer requested that the session be closed.                                                                                 |
| 47         | NCP-Closed-PPP             | PPP session closed because there were no NCPs open.                                                                               |
| 48         | MP-Error-PPP               | PPP session closed because of an MP error.                                                                                        |
| 49         | PPP-Maximum-Channels       | PPP session closed because maximum channels were reached.                                                                         |
| 50         | Tables-Full                | Disconnect due to full terminal server tables.                                                                                    |
| 51         | Resources-Full             | Disconnect due to full internal resources.                                                                                        |
| 52         | Invalid-IP-Address         | IP address is not valid for Telnet host.                                                                                          |
| 53         | Bad-Hostname               | Hostname cannot be validated.                                                                                                     |



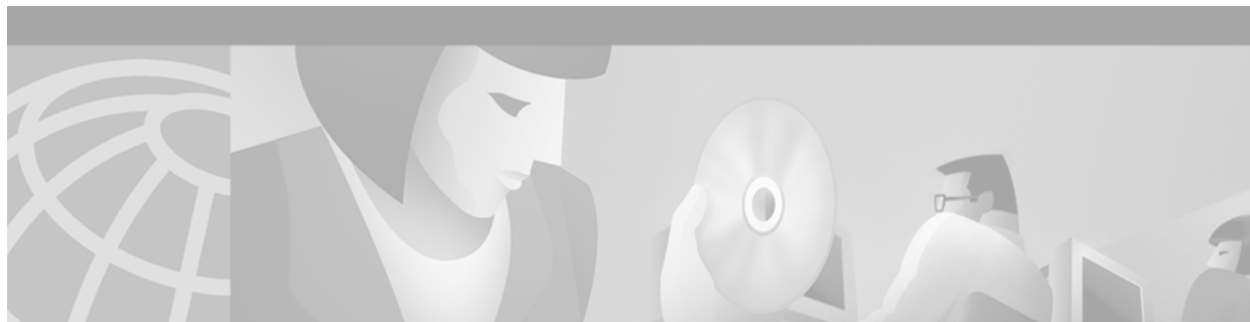
**Table 37** Disconnect-Cause Attribute Values (continued)

| Cause Code | Value                         | Description                                                                                                                                                                                                                                                                                                                                                                                           |
|------------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 54         | Bad-Port                      | Port number is invalid or missing.                                                                                                                                                                                                                                                                                                                                                                    |
| 60         | Reset-TCP                     | TCP connection has been reset.<br><b>Note</b> Codes 60 through 67 apply to Telnet or raw TCP sessions.                                                                                                                                                                                                                                                                                                |
| 61         | TCP-Connection-Refused        | TCP connection has been refused by the host.                                                                                                                                                                                                                                                                                                                                                          |
| 62         | Timeout-TCP                   | TCP connection has timed out.                                                                                                                                                                                                                                                                                                                                                                         |
| 63         | Foreign-Host-Close-TCP        | TCP connection has been closed.                                                                                                                                                                                                                                                                                                                                                                       |
| 64         | TCP-Network-Unreachable       | TCP network is unreachable.                                                                                                                                                                                                                                                                                                                                                                           |
| 65         | TCP-Host-Unreachable          | TCP host is unreachable.                                                                                                                                                                                                                                                                                                                                                                              |
| 66         | TCP-Network-Admin Unreachable | TCP network is unreachable for administrative reasons.                                                                                                                                                                                                                                                                                                                                                |
| 67         | TCP-Port-Unreachable          | TCP port is unreachable.                                                                                                                                                                                                                                                                                                                                                                              |
| 100        | Session-Timeout               | Session timed out.                                                                                                                                                                                                                                                                                                                                                                                    |
| 101        | Session-Failed-Security       | Session failed for security reasons.                                                                                                                                                                                                                                                                                                                                                                  |
| 102        | Session-End-Callback          | Session terminated due to callback.                                                                                                                                                                                                                                                                                                                                                                   |
| 120        | Invalid-Protocol              | Call refused because the detected protocol is disabled.                                                                                                                                                                                                                                                                                                                                               |
| 150        | RADIUS-Disconnect             | Disconnected by RADIUS request.                                                                                                                                                                                                                                                                                                                                                                       |
| 151        | Local-Admin-Disconnect        | Administrative disconnect.                                                                                                                                                                                                                                                                                                                                                                            |
| 152        | SNMP-Disconnect               | Disconnected by SNMP request.                                                                                                                                                                                                                                                                                                                                                                         |
| 160        | V110-Retries                  | Allowed V.110 retries have been exceeded.                                                                                                                                                                                                                                                                                                                                                             |
| 170        | PPP-Authentication-Timeout    | PPP authentication timed out.                                                                                                                                                                                                                                                                                                                                                                         |
| 180        | Local-Hangup                  | Disconnected by local hangup.                                                                                                                                                                                                                                                                                                                                                                         |
| 185        | Remote-Hangup                 | Disconnected by remote end hangup.                                                                                                                                                                                                                                                                                                                                                                    |
| 190        | T1-Quiesced                   | Disconnected because T1 line was quiesced.                                                                                                                                                                                                                                                                                                                                                            |
| 195        | Call-Duration                 | Disconnected because the maximum duration of the call was exceeded.                                                                                                                                                                                                                                                                                                                                   |
| 600        | VPN-User-Disconnect           | Call disconnected by client (through PPP).<br>Code is sent if the LNS receives a PPP terminate request from the client.                                                                                                                                                                                                                                                                               |
| 601        | VPN-Carrier-Loss              | Loss of carrier. This can be the result of a physical line going dead.<br>Code is sent when a client is unable to dial out using a dialer.                                                                                                                                                                                                                                                            |
| 602        | VPN-No-Resources              | No resources available to handle the call.<br>Code is sent when the client is unable to allocate memory (running low on memory).                                                                                                                                                                                                                                                                      |
| 603        | VPN-Bad-Control-Packet        | Bad L2TP or L2F control packets.<br><br>This code is sent when an invalid control packet, such as missing mandatory Attribute-Value pairs (AVP), from the peer is received. When using L2TP, the code will be sent after six retransmits; when using L2F, the number of retransmits is user configurable.<br><br><b>Note</b> VPN-Tunnel-Shut will be sent if there are active sessions in the tunnel. |

**Table 37** Disconnect-Cause Attribute Values (continued)

| Cause Code | Value                | Description                                                                                                                                                                                                                                                    |
|------------|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 604        | VPN-Admin-Disconnect | Administrative disconnect. This can be the result of a VPN soft shutdown, which is when a client reaches maximum session limit or exceeds maximum hopcount.<br><br>Code is sent when a tunnel is brought down by issuing the <b>clear vpdn tunnel</b> command. |
| 605        | VPN-Tunnel-Shut      | Tunnel teardown or tunnel setup has failed.<br><br>Code is sent when there are active sessions in a tunnel and the tunnel goes down.<br><b>Note</b> This code is <i>not</i> sent when tunnel authentication fails.                                             |
| 606        | VPN-Local-Disconnect | Call is disconnected by LNS PPP module.<br><br>Code is sent when the LNS sends a PPP terminate request to the client. It indicates a normal PPP disconnection initiated by the LNS.                                                                            |
| 607        | VPN-Session-Limit    | VPN soft shutdown is enabled.<br><br>Code is sent when a call has been refused due to any of the soft shutdown restrictions previously mentioned.                                                                                                              |
| 608        | VPN-Call-Redirect    | VPN call redirect is enabled.                                                                                                                                                                                                                                  |

For Q.850 cause codes and descriptions, see the section “Internal Cause Codes for SIP and H.323” in the chapter “Cause Codes and Debug Values” of the *Cisco IOS Voice Troubleshooting and Monitoring*.



## TACACS+ Attribute-Value Pairs

Terminal Access Controller Access Control System Plus (TACACS+) attribute-value (AV) pairs are used to define specific authentication, authorization, and accounting elements in a user profile that is stored on the TACACS+ daemon. This appendix lists the TACACS+ AV pairs currently supported.

### How to Use This Appendix

This appendix is divided into two sections:

- [TACACS+ Authentication and Authorization AV Pairs](#)
- [TACACS+ Accounting AV Pairs](#)

The first section lists and describes the supported TACACS+ authentication and authorization AV pairs, and it specifies the Cisco IOS release in which they are implemented. The second section lists and describes the supported TACACS+ accounting AV pairs, and it specifies the Cisco IOS release in which they are implemented.

### TACACS+ Authentication and Authorization AV Pairs

[Table 38](#) lists and describes the supported TACACS+ authentication and authorization AV pairs and specifies the Cisco IOS release in which they are implemented.

**Table 38** Supported TACACS+ Authentication and Authorization AV Pairs

| Attribute | Description                                                                                                                                                                                      | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| acl=x     | ASCII number representing a connection access list. Used only when service=shell.                                                                                                                | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| addr=x    | A network address. Used with service=slip, service=ppp, and protocol=ip. Contains the IP address that the remote host should use when connecting via SLIP or PPP/IP. For example, addr=10.2.3.4. | yes  | yes  | yes  | yes  | yes  | yes  | yes  |

**Table 38 Supported TACACS+ Authentication and Authorization AV Pairs (continued)**

| Attribute           | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| addr-pool=x         | <p>Specifies the name of a local pool from which to get the address of the remote host. Used with service=ppp and protocol=ip.</p> <p>Note that <b>addr-pool</b> works in conjunction with local pooling. It specifies the name of a local pool (which must be preconfigured on the network access server). Use the <b>ip-local pool</b> command to declare local pools. For example:</p> <pre>ip address-pool local ip local pool boo 10.0.0.1 10.0.0.10 ip local pool moo 10.0.0.1 10.0.0.20</pre> <p>You can then use TACACS+ to return addr-pool=boo or addr-pool=moo to indicate the address pool from which you want to get this remote node's address.</p> | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| autocmd=x           | Specifies an autocommand to be executed at EXEC startup (for example, autocmd=telnet example.com). Used only with service=shell.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| callback-dialstring | Sets the telephone number for a callback (for example: callback-dialstring=408-555-1212). Value is NULL, or a dial-string. A NULL value indicates that the service might choose to get the dial string through other means. Used with service=arap, service=slip, service=ppp, service=shell. Not valid for ISDN.                                                                                                                                                                                                                                                                                                                                                 | no   | yes  | yes  | yes  | yes  | yes  | yes  |
| callback-line       | The number of a TTY line to use for callback (for example: callback-line=4). Used with service=arap, service=slip, service=ppp, service=shell. Not valid for ISDN.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | no   | yes  | yes  | yes  | yes  | yes  | yes  |
| callback-rotary     | The number of a rotary group (between 0 and 100 inclusive) to use for callback (for example: callback-rotary=34). Used with service=arap, service=slip, service=ppp, service=shell. Not valid for ISDN.                                                                                                                                                                                                                                                                                                                                                                                                                                                           | no   | yes  | yes  | yes  | yes  | yes  | yes  |
| cmd-arg=x           | <p>An argument to a shell (EXEC) command. This indicates an argument for the shell command that is to be run. Multiple cmd-arg attributes can be specified, and they are order dependent.</p> <p><b>Note</b> This TACACS+ AV pair cannot be used with RADIUS attribute 26.</p>                                                                                                                                                                                                                                                                                                                                                                                    | yes  | yes  | yes  | yes  | yes  | yes  | yes  |

**Table 38** Supported TACACS+ Authentication and Authorization AV Pairs (continued)

| Attribute    | Description                                                                                                                                                                                                                                                                                                    | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| cmd=x        | A shell (EXEC) command. This indicates the command name for a shell command that is to be run. This attribute must be specified if service equals "shell." A NULL value indicates that the shell itself is being referred to.<br><br><b>Note</b> This TACACS+ AV pair cannot be used with RADIUS attribute 26. | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| data-service | Used with the service=outbound and protocol=ip.                                                                                                                                                                                                                                                                | no   | no   | no   | no   | no   | yes  | yes  |
| dial-number  | Defines the number to dial. Used with the service=outbound and protocol=ip.                                                                                                                                                                                                                                    | no   | no   | no   | no   | no   | yes  | yes  |
| dns-servers= | Identifies a DNS server (primary or secondary) that can be requested by Microsoft PPP clients from the network access server during IPCP negotiation. To be used with service=ppp and protocol=ip. The IP address identifying each DNS server is entered in dotted decimal format.                             | no   | no   | no   | yes  | yes  | yes  | yes  |
| force-56     | Determines whether the network access server uses only the 56 K portion of a channel, even when all 64 K appear to be available. To turn on this attribute, use the "true" value (force-56=true). Any other value is treated as false. Used with the service=outbound and protocol=ip.                         | no   | no   | no   | no   | no   | yes  | yes  |
| gw-password  | Specifies the password for the home gateway during the L2F tunnel authentication. Used with service=ppp and protocol=vpdn.                                                                                                                                                                                     | no   | no   | yes  | yes  | yes  | yes  | yes  |
| idletime=x   | Sets a value, in minutes, after which an idle session is terminated. A value of zero indicates no timeout.                                                                                                                                                                                                     | no   | yes  | yes  | yes  | yes  | yes  | yes  |
| inac1#<n>    | ASCII access list identifier for an input access list to be installed and applied to an interface for the duration of the current connection. Used with service=ppp and protocol=ip, and service service=ppp and protocol=ipx. Per-user access lists do not currently work with ISDN interfaces.               | no   | no   | no   | yes  | yes  | yes  | yes  |
| inac1=x      | ASCII identifier for an interface input access list. Used with service=ppp and protocol=ip. Per-user access lists do not currently work with ISDN interfaces.                                                                                                                                                  | yes  | yes  | yes  | yes  | yes  | yes  | yes  |

**Table 38 Supported TACACS+ Authentication and Authorization AV Pairs (continued)**

| Attribute                 | Description                                                                                                                                                                                                                                                                                                                                                                                                         | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| interface-config#<br><n>  | Specifies user-specific AAA interface configuration information with Virtual Profiles. The information that follows the equal sign (=) can be any Cisco IOS interface configuration command. Multiple instances of the attributes are allowed, but each instance must have a unique number. Used with service=ppp and protocol=lcp.<br><br><b>Note</b> This attribute replaces the “interface-config=” attribute.   | no   | no   | no   | yes  | yes  | yes  | yes  |
| ip-addresses              | Space-separated list of possible IP addresses that can be used for the end-point of a tunnel. Used with service=ppp and protocol=vpdn.                                                                                                                                                                                                                                                                              | no   | no   | yes  | yes  | yes  | yes  | yes  |
| l2tp-busy-disconnect      | If a vpdn-group on an LNS uses a virtual-template that is configured to be pre-cloned, this attribute will control the disposition of a new L2TP session that finds no pre-cloned interface to which to connect. If the attribute is true (the default), the session will be disconnected by the LNS. Otherwise, a new interface will be cloned from the virtual-template. Used with service=ppp and protocol=vpdn. | no   | no   | no   | no   | no   | yes  | yes  |
| l2tp-cm-local-window-size | Specifies the maximum receive window size for L2TP control messages. This value is advertised to the peer during tunnel establishment. Used with service=ppp and protocol=vpdn.                                                                                                                                                                                                                                     | no   | no   | no   | no   | no   | yes  | yes  |
| l2tp-drop-out-of-order    | Respects sequence numbers on data packets by dropping those that are received out of order. This does not ensure that sequence numbers will be sent on data packets, just how to handle them if they are received. Used with service=ppp and protocol=vpdn.                                                                                                                                                         | no   | no   | no   | no   | no   | yes  | yes  |
| l2tp-hello-interval       | Specifies the number of seconds for the hello keepalive interval. Hello packets are sent when no data has been sent on a tunnel for the number of seconds configured here. Used with service=ppp and protocol=vpdn.                                                                                                                                                                                                 | no   | no   | no   | no   | no   | yes  | yes  |
| l2tp-hidden-avp           | When enabled, sensitive AVPs in L2TP control messages are scrambled or hidden. Used with service=ppp and protocol=vpdn.                                                                                                                                                                                                                                                                                             | no   | no   | no   | no   | no   | yes  | yes  |
| l2tp-nosession-timeout    | Specifies the number of seconds that a tunnel will stay active with no sessions before timing out and shutting down. Used with service=ppp and protocol=vpdn.                                                                                                                                                                                                                                                       | no   | no   | no   | no   | no   | yes  | yes  |

**Table 38 Supported TACACS+ Authentication and Authorization AV Pairs (continued)**

| Attribute            | Description                                                                                                                                                                                                                                                                                                                                         | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| l2tp-tos-reflect     | Copies the IP ToS field from the IP header of each payload packet to the IP header of the tunnel packet for packets entering the tunnel at the LNS. Used with service=ppp and protocol=vpdn.                                                                                                                                                        | no   | no   | no   | no   | no   | yes  | yes  |
| l2tp-tunnel-authen   | If this attribute is set, it performs L2TP tunnel authentication. Used with service=ppp and protocol=vpdn.                                                                                                                                                                                                                                          | no   | no   | no   | no   | no   | yes  | yes  |
| l2tp-tunnel-password | Shared secret used for L2TP tunnel authentication and AVP hiding. Used with service=ppp and protocol=vpdn.                                                                                                                                                                                                                                          | no   | no   | no   | no   | no   | yes  | yes  |
| l2tp-udp-checksum    | This is an authorization attribute and defines whether L2TP should perform UDP checksums for data packets. Valid values are “yes” and “no.” The default is no. Used with service=ppp and protocol=vpdn.                                                                                                                                             | no   | no   | no   | no   | no   | yes  | yes  |
| link-compression=    | Defines whether to turn on or turn off “stac” compression over a PPP link. Used with service=ppp.<br><br>Link compression is defined as a numeric value as follows: <ul style="list-style-type: none"> <li>• 0: None</li> <li>• 1: Stac</li> <li>• 2: Stac-Draft-9</li> <li>• 3: MS-Stac</li> </ul>                                                 | no   | no   | no   | yes  | yes  | yes  | yes  |
| load-threshold=<n>   | Sets the load threshold for the caller at which additional links are either added to or deleted from the multilink bundle. If the load goes above the specified value, additional links are added. If the load goes below the specified value, links are deleted. Used with service=ppp and protocol=multilink. The range for <n> is from 1 to 255. | no   | no   | no   | yes  | yes  | yes  | yes  |
| map-class            | Allows the user profile to reference information configured in a map class of the same name on the network access server that dials out. Used with the service=outbound and protocol=ip.                                                                                                                                                            | no   | no   | no   | no   | no   | yes  | yes  |
| max-links=<n>        | Restricts the number of links that a user can have in a multilink bundle. Used with service=ppp and protocol=multilink. The range for <n> is from 1 to 255.                                                                                                                                                                                         | no   | no   | no   | yes  | yes  | yes  | yes  |
| min-links            | Sets the minimum number of links for MLP. Used with service=ppp and protocol=multilink, protocol=vpdn.                                                                                                                                                                                                                                              | no   | no   | no   | no   | no   | yes  | yes  |

**Table 38 Supported TACACS+ Authentication and Authorization AV Pairs (continued)**

| Attribute         | Description                                                                                                                                                                                                                                                                                                                                        | 11.0                            | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|------|------|------|------|------|------|
| nas-password      | Specifies the password for the network access server during the L2F tunnel authentication. Used with service=ppp and protocol=vpdn.                                                                                                                                                                                                                | no                              | no   | yes  | yes  | yes  | yes  | yes  |
| nocallback-verify | Indicates that no callback verification is required. The only valid value for this parameter is 1 (for example, nocallback-verify=1). Used with service=arap, service=slip, service=ppp, service=shell. There is no authentication on callback. Not valid for ISDN.                                                                                | no                              | yes  | yes  | yes  | yes  | yes  | yes  |
| noescape=x        | Prevents user from using an escape character. Used with service=shell. Can be either true or false (for example, noescape=true).                                                                                                                                                                                                                   | yes                             | yes  | yes  | yes  | yes  | yes  | yes  |
| nohangup=x        | Used with service=shell. Specifies the nohangup option, which means that after an EXEC shell is terminated, the user is presented with another login (username) prompt. Can be either true or false (for example, nohangup=false).                                                                                                                 | yes                             | yes  | yes  | yes  | yes  | yes  | yes  |
| old-prompts       | Allows providers to make the prompts in TACACS+ appear identical to those of earlier systems (TACACS and Extended TACACS). This allows administrators to upgrade from TACACS or Extended TACACS to TACACS+ transparently to users.                                                                                                                 | yes                             | yes  | yes  | yes  | yes  | yes  | yes  |
| outacl#<n>        | ASCII access list identifier for an interface output access list to be installed and applied to an interface for the duration of the current condition. Used with service=ppp and protocol=ip, and service service=ppp and protocol=ipx. Per-user access lists do not currently work with ISDN interfaces.                                         | no                              | no   | no   | yes  | yes  | yes  | yes  |
| outacl=x          | ASCII identifier for an interface output access list. Used with service=ppp and protocol=ip, and service service=ppp and protocol=ipx. Contains an IP output access list for SLIP or PPP/IP (for example, outacl=4). The access list itself must be preconfigured on the router. Per-user access lists do not currently work with ISDN interfaces. | yes<br>(PPP<br>/IP<br>only<br>) | yes  | yes  | yes  | yes  | yes  | yes  |
| pool-def#<n>      | Defines IP address pools on the network access server. Used with service=ppp and protocol=ip.                                                                                                                                                                                                                                                      | no                              | no   | no   | yes  | yes  | yes  | yes  |



**Table 38** Supported TACACS+ Authentication and Authorization AV Pairs (continued)

| Attribute               | Description                                                                                                                                                                                                                                                                                                                                                                                                                                     | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| pool-timeout=           | Defines (in conjunction with pool-def) IP address pools on the network access server. During IPCP address negotiation, if an IP pool name is specified for a user (see the addr-pool attribute), a check is made to see if the named pool is defined on the network access server. If it is, the pool is consulted for an IP address. Used with service=ppp and protocol=ip.                                                                    | no   | no   | yes  | yes  | yes  | yes  | yes  |
| port-type               | Indicates the type of physical port the network access server is using to authenticate the user.<br><br>Physical ports are indicated by a numeric value as follows: <ul style="list-style-type: none"> <li>• 0: Asynchronous</li> <li>• 1: Synchronous</li> <li>• 2: ISDN-Synchronous</li> <li>• 3: ISDN-Asynchronous (V.120)</li> <li>• 4: ISDN- Asynchronous (V.110)</li> <li>• 5: Virtual</li> </ul> Used with service=any and protocol=aaa. | no   | no   | no   | no   | no   | yes  | yes  |
| ppp-vj-slot-compression | Instructs the Cisco router not to use slot compression when sending VJ-compressed packets over a PPP link.                                                                                                                                                                                                                                                                                                                                      | no   | no   | no   | yes  | yes  | yes  | yes  |
| priv-lvl=x              | Privilege level to be assigned for the EXEC. Used with service=shell. Privilege levels range from 0 to 15, with 15 being the highest.                                                                                                                                                                                                                                                                                                           | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| protocol=x              | A protocol that is a subset of a service. An example would be any PPP NCP. Currently known values are <b>lcp, ip, ipx, atalk, vines, lat, xremote, tn3270, telnet, rlogin, pad, vpdn, osicp, deccp, ccp, cdp, bridging, xns, nbf, bap, multilink</b> , and <b>unknown</b> .                                                                                                                                                                     | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| proxyacl#<n>            | Allows users to configure the downloadable user profiles (dynamic ACLs) by using the authentication proxy feature so that users can have the configured authorization to permit traffic going through the configured interfaces. Used with the service=shell and protocol=exec.                                                                                                                                                                 | no   | no   | no   | no   | no   | yes  | yes  |

**Table 38 Supported TACACS+ Authentication and Authorization AV Pairs (continued)**

| Attribute        | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| route            | <p>Specifies a route to be applied to an interface. Used with service=slip, service=ppp, and protocol=ip.</p> <p>During network authorization, the route attribute can be used to specify a per-user static route, to be installed by TACACS+ as follows:</p> <pre>route="dst_address mask [gateway]"</pre> <p>This indicates a temporary static route that is to be applied. The <i>dst_address</i>, <i>mask</i>, and <i>gateway</i> are expected to be in the usual dotted-decimal notation, with the same meanings as in the familiar <b>ip route</b> configuration command on a network access server.</p> <p>If <i>gateway</i> is omitted, the peer's address is the gateway. The route is expunged when the connection terminates.</p> | no   | yes  | yes  | yes  | yes  | yes  | yes  |
| route#<n>        | Like the route AV pair, this specifies a route to be applied to an interface, but these routes are numbered, allowing multiple routes to be applied. Used with service=ppp and protocol=ip, and service=ppp and protocol=ipx.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | no   | no   | no   | yes  | yes  | yes  | yes  |
| routing=x        | Specifies whether routing information is to be propagated to and accepted from this interface. Used with service=slip, service=ppp, and protocol=ip. Equivalent in function to the /routing flag in SLIP and PPP commands. Can either be true or false (for example, routing=true).                                                                                                                                                                                                                                                                                                                                                                                                                                                          | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| rte-fltr-in#<n>  | Specifies an input access list definition to be installed and applied to routing updates on the current interface for the duration of the current connection. Used with service=ppp and protocol=ip, and with service=ppp and protocol=ipx.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | no   | no   | no   | yes  | yes  | yes  | yes  |
| rte-fltr-out#<n> | Specifies an output access list definition to be installed and applied to routing updates on the current interface for the duration of the current connection. Used with service=ppp and protocol=ip, and with service=ppp and protocol=ipx.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | no   | no   | no   | yes  | yes  | yes  | yes  |
| sap#<n>          | Specifies static Service Advertising Protocol (SAP) entries to be installed for the duration of a connection. Used with service=ppp and protocol=ipx.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | no   | no   | no   | yes  | yes  | yes  | yes  |

**Table 38 Supported TACACS+ Authentication and Authorization AV Pairs (continued)**

| Attribute        | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| sap-fltr-in#<n>  | Specifies an input SAP filter access list definition to be installed and applied on the current interface for the duration of the current connection. Used with service=ppp and protocol=ipx.                                                                                                                                                                                                                                                                                                                               | no   | no   | no   | yes  | yes  | yes  | yes  |
| sap-fltr-out#<n> | Specifies an output SAP filter access list definition to be installed and applied on the current interface for the duration of the current connection. Used with service=ppp and protocol=ipx.                                                                                                                                                                                                                                                                                                                              | no   | no   | no   | yes  | yes  | yes  | yes  |
| send-auth        | Defines the protocol to use (PAP or CHAP) for username-password authentication following CLID authentication. Used with service=any and protocol=aaa.                                                                                                                                                                                                                                                                                                                                                                       | no   | no   | no   | no   | no   | yes  | yes  |
| send-secret      | Specifies the password that the NAS needs to respond to a chap/pap request from the remote end of a connection on an outgoing call. Used with service=ppp and protocol=ip.                                                                                                                                                                                                                                                                                                                                                  | no   | no   | no   | no   | no   | yes  | yes  |
| service=x        | The primary service. Specifying a service attribute indicates that this is a request for authorization or accounting of that service. Current values are <b>slip</b> , <b>ppp</b> , <b>arap</b> , <b>shell</b> , <b>tty-daemon</b> , <b>connection</b> , and <b>system</b> . This attribute must always be included.                                                                                                                                                                                                        | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| source-ip=x      | Used as the source IP address of all VPDN packets generated as part of a VPDN tunnel. This is equivalent to the Cisco <b>vpdn outgoing</b> global configuration command.                                                                                                                                                                                                                                                                                                                                                    | no   | no   | yes  | yes  | yes  | yes  | yes  |
| spi              | Carries the authentication information needed by the home agent to authenticate a mobile node during registration. The information is in the same syntax as the <b>ip mobile secure host &lt;addr&gt;</b> configuration command. Basically it contains the rest of the configuration command that follows that string, verbatim. It provides the Security Parameter Index (SPI), key, authentication algorithm, authentication mode, and replay protection timestamp range. Used with the service=mobileip and protocol=ip. | no   | no   | no   | no   | no   | yes  | yes  |
| timeout=x        | The number of minutes before an EXEC or ARA session disconnects (for example, timeout=60). A value of zero indicates no timeout. Used with service=arap.                                                                                                                                                                                                                                                                                                                                                                    | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| tunnel-id        | Specifies the username that will be used to authenticate the tunnel over which the individual user MID will be projected. This is analogous to the <i>remote name</i> in the <b>vpdn outgoing</b> command. Used with service=ppp and protocol=vpdn.                                                                                                                                                                                                                                                                         | no   | no   | yes  | yes  | yes  | yes  | yes  |

**Table 38 Supported TACACS+ Authentication and Authorization AV Pairs (continued)**

| Attribute     | Description                                                                                                                                                                                                                                                               | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| wins-servers= | Identifies a Windows NT server that can be requested by Microsoft PPP clients from the network access server during IPCP negotiation. To be used with service=ppp and protocol=ip. The IP address identifying each Windows NT server is entered in dotted decimal format. | no   | no   | no   | yes  | yes  | yes  | yes  |
| zonelist=x    | A numeric zonelist value. Used with service=arap. Specifies an AppleTalk zonelist for ARA (for example, zonelist=5).                                                                                                                                                      | yes  | yes  | yes  | yes  | yes  | yes  | yes  |

For more information about configuring TACACS+, refer to the chapter “Configuring TACACS+.” For more information about configuring TACACS+ authentication and authorization, refer to the chapters “Configuring Authentication” and “Configuring Authorization.”

## TACACS+ Accounting AV Pairs

[Table 39](#) lists and describes the supported TACACS+ accounting AV pairs and specifies the Cisco IOS release in which they are implemented.

**Table 39 Supported TACACS+ Accounting AV Pairs**

| Attribute   | Description                                                                                                                                                                                                                                                                                                                                                                     | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| Abort-Cause | If the fax session aborts, indicates the system component that signaled the abort. Examples of system components that could trigger an abort are FAP (Fax Application Process), TIFF (the TIFF reader or the TIFF writer), fax-mail client, fax-mail server, ESMTP client, or ESMTP server.                                                                                     | no   | no   | no   | no   | no   | yes  | yes  |
| bytes_in    | The number of input bytes transferred during this connection.                                                                                                                                                                                                                                                                                                                   | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| bytes_out   | The number of output bytes transferred during this connection.                                                                                                                                                                                                                                                                                                                  | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| Call-Type   | Describes the type of fax activity: fax receive or fax send.                                                                                                                                                                                                                                                                                                                    | no   | no   | no   | no   | no   | yes  | yes  |
| cmd         | The command the user executed.                                                                                                                                                                                                                                                                                                                                                  | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| data-rate   | This AV pair has been renamed. See nas-rx-speed.                                                                                                                                                                                                                                                                                                                                |      |      |      |      |      |      |      |
| disc-cause  | Specifies the reason a connection was taken off-line. The Disconnect-Cause attribute is sent in accounting-stop records. This attribute also causes stop records to be generated without first generating start records if disconnection occurs before authentication is performed. Refer to <a href="#">Table 40</a> for a list of Disconnect-Cause values and their meanings. | no   | no   | no   | yes  | yes  | yes  | yes  |

**Table 39 Supported TACACS+ Accounting AV Pairs (continued)**

| Attribute             | Description                                                                                                                                                                                                                                                                                                  | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| disc-cause-ext        | Extends the disc-cause attribute to support vendor-specific reasons why a connection was taken off-line.                                                                                                                                                                                                     | no   | no   | no   | yes  | yes  | yes  | yes  |
| elapsed_time          | The elapsed time in seconds for the action. Useful when the device does not keep real time.                                                                                                                                                                                                                  | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| Email-Server-Address  | Indicates the IP address of the e-mail server handling the on-ramp fax-mail message.                                                                                                                                                                                                                         | no   | no   | no   | no   | no   | yes  | yes  |
| Email-Server-Ack-Flag | Indicates that the on-ramp gateway has received a positive acknowledgment from the e-mail server accepting the fax-mail message.                                                                                                                                                                             | no   | no   | no   | no   | no   | yes  | yes  |
| event                 | Information included in the accounting packet that describes a state change in the router. Events described are accounting starting and accounting stopping.                                                                                                                                                 | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| Fax-Account-Id-Origin | Indicates the account ID origin as defined by system administrator for the <b>mmoip aaa receive-id</b> or the <b>mmoip aaa send-id</b> command.                                                                                                                                                              | no   | no   | no   | no   | no   | yes  | yes  |
| Fax-Auth-Status       | Indicates whether or not authentication for this fax session was successful. Possible values for this field are success, failed, bypassed, or unknown.                                                                                                                                                       | no   | no   | no   | no   | no   | yes  | yes  |
| Fax-Connect-Speed     | Indicates the modem speed at which this fax-mail was initially transmitted or received. Possible values are 1200, 4800, 9600, and 14400.                                                                                                                                                                     | no   | no   | no   | no   | no   | yes  | yes  |
| Fax-Coverpage-Flag    | Indicates whether or not a cover page was generated by the off-ramp gateway for this fax session. True indicates that a cover page was generated; false means that a cover page was not generated.                                                                                                           | no   | no   | no   | no   | no   | yes  | yes  |
| Fax-Dsn-Address       | Indicates the address to which DSNs will be sent.                                                                                                                                                                                                                                                            | no   | no   | no   | no   | no   | yes  | yes  |
| Fax-Dsn-Flag          | Indicates whether or not DSN has been enabled. True indicates that DSN has been enabled; false means that DSN has not been enabled.                                                                                                                                                                          | no   | no   | no   | no   | no   | yes  | yes  |
| Fax-Mdn-Address       | Indicates the address to which MDNs will be sent.                                                                                                                                                                                                                                                            | no   | no   | no   | no   | no   | yes  | yes  |
| Fax-Mdn-Flag          | Indicates whether or not message delivery notification (MDN) has been enabled. True indicates that MDN had been enabled; false means that MDN had not been enabled.                                                                                                                                          | no   | no   | no   | no   | no   | yes  | yes  |
| Fax-Modem-Time        | Indicates the amount of time in seconds the modem sent fax data (x) and the amount of time in seconds of the total fax session (y), which includes both fax-mail and PSTN time, in the form x/y. For example, 10/15 means that the transfer time took 10 seconds, and the total fax session took 15 seconds. | no   | no   | no   | no   | no   | yes  | yes  |

**Table 39 Supported TACACS+ Accounting AV Pairs (continued)**

| Attribute              | Description                                                                                                                                                                                                           | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| Fax-Msg-Id=            | Indicates a unique fax message identification number assigned by Store and Forward Fax.                                                                                                                               | no   | no   | no   | no   | no   | yes  | yes  |
| Fax-Pages              | Indicates the number of pages transmitted or received during this fax session. This page count includes cover pages.                                                                                                  | no   | no   | no   | no   | no   | yes  | yes  |
| Fax-Process-Abort-Flag | Indicates that the fax session was aborted or successful. True means that the session was aborted; false means that the session was successful.                                                                       | no   | no   | no   | no   | no   | yes  | yes  |
| Fax-Recipient-Count    | Indicates the number of recipients for this fax transmission. Until e-mail servers support Session mode, the number should be 1.                                                                                      | no   | no   | no   | no   | no   | yes  | yes  |
| Gateway-Id             | Indicates the name of the gateway that processed the fax session. The name appears in the following format: hostname.domain-name                                                                                      | no   | no   | no   | no   | no   | yes  | yes  |
| mlp-links-max          | Gives the count of links which are known to have been in a given multilink session at the time the accounting record is generated.                                                                                    | no   | no   | no   | yes  | yes  | yes  | yes  |
| mlp-sess-id            | Reports the identification number of the multilink bundle when the session closes. This attribute applies to sessions that are part of a multilink bundle. This attribute is sent in authentication-response packets. | no   | no   | no   | yes  | yes  | yes  | yes  |
| nas-rx-speed           | Specifies the average number of bits per second over the course of the connection's lifetime. This attribute is sent in accounting-stop records.                                                                      | no   | no   | no   | yes  | yes  | yes  | yes  |
| nas-tx-speed           | Reports the transmit speed negotiated by the two modems.                                                                                                                                                              | no   | no   | no   | yes  | yes  | yes  | yes  |
| paks_in                | The number of input packets transferred during this connection.                                                                                                                                                       | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| paks_out               | The number of output packets transferred during this connection.                                                                                                                                                      | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| port                   | The port the user was logged in to.                                                                                                                                                                                   | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| Port-Used              | Indicates the slot/port number of the Cisco AS5300 used to either transmit or receive this fax-mail.                                                                                                                  | no   | no   | no   | no   | no   | yes  | yes  |
| pre-bytes-in           | Records the number of input bytes before authentication. This attribute is sent in accounting-stop records.                                                                                                           | no   | no   | no   | yes  | yes  | yes  | yes  |
| pre-bytes-out          | Records the number of output bytes before authentication. This attribute is sent in accounting-stop records.                                                                                                          | no   | no   | no   | yes  | yes  | yes  | yes  |
| pre-paks-in            | Records the number of input packets before authentication. This attribute is sent in accounting-stop records.                                                                                                         | no   | no   | no   | yes  | yes  | yes  | yes  |

**Table 39 Supported TACACS+ Accounting AV Pairs (continued)**

| Attribute        | Description                                                                                                                                                                                                     | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| pre-paks-out     | Records the number of output packets before authentication. The Pre-Output-Packets attribute is sent in accounting-stop records.                                                                                | no   | no   | no   | yes  | yes  | yes  | yes  |
| pre-session-time | Specifies the length of time, in seconds, from when a call first connects to when it completes authentication.                                                                                                  | no   | no   | no   | yes  | yes  | yes  | yes  |
| priv_level       | The privilege level associated with the action.                                                                                                                                                                 | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| protocol         | The protocol associated with the action.                                                                                                                                                                        | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| reason           | Information included in the accounting packet that describes the event that caused a system change. Events described are system reload, system shutdown, or when accounting is reconfigured (turned on or off). | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| service          | The service the user used.                                                                                                                                                                                      | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| start_time       | The time the action started (in seconds since the epoch, 12:00 a.m. Jan 1 1970). The clock must be configured to receive this information.                                                                      | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| stop_time        | The time the action stopped (in seconds since the epoch.) The clock must be configured to receive this information.                                                                                             | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| task_id          | Start and stop records for the same event must have matching (unique) task_id numbers.                                                                                                                          | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| timezone         | The time zone abbreviation for all timestamps included in this packet.                                                                                                                                          | yes  | yes  | yes  | yes  | yes  | yes  | yes  |
| xmit-rate        | This AV pair has been renamed. See nas-tx-speed.                                                                                                                                                                |      |      |      |      |      |      |      |

Table 40 lists the cause codes and descriptions for the Disconnect Cause Extended (disc-cause-ext) attribute.

**Table 40 Disconnect Cause Extensions**

| Cause Codes            | Description                                                                                          | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 | 12.3 |
|------------------------|------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|
| 1000 – No Reason       | No reason for the disconnect.                                                                        | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1001 – No Disconnect   | The event was not a disconnect.                                                                      | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1002 – Unknown         | The reason for the disconnect is unknown. This code can appear when the remote connection goes down. | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1003 – Call Disconnect | The call has disconnected.                                                                           | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1004 – CLID Auth Fail  | Calling line ID (CLID) authentication has failed.                                                    | no   | no   | no   | no   | yes  | yes  | yes  | yes  |

| Cause Codes               | Description                                                                                                                                                                                                                                                             | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 | 12.3 |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|
| 1009 – No Modem Available | The modem is not available.                                                                                                                                                                                                                                             | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1010 – No Carrier         | The modem never detected data carrier detect (DCD). This code can appear if a disconnect occurs during the initial modem connection.                                                                                                                                    | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1011 – Lost Carrier       | The modem detected DCD but became inactive. This code can appear if a disconnect occurs during the initial modem connection.                                                                                                                                            | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1012 – No Modem Results   | The result codes could not be parsed. This code can appear if a disconnect occurs during the initial modem connection.                                                                                                                                                  | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1020 – TS User Exit       | The user exited normally from the terminal server. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                                                                                                                   | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1021 – Idle Timeout       | The user exited from the terminal server because the idle timer expired. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                                                                                             | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1022 – TS Exit Telnet     | The user exited normally from a Telnet session. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                                                                                                                      | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1023 – TS No IP Addr      | The user could not switch to Serial Line Internet Protocol (SLIP) or PPP because the remote host had no IP address or because the dynamic pool could not assign one. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session. | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1024 – TS TCP Raw Exit    | The user exited normally from a raw TCP session. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                                                                                                                     | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1025 – TS Bad Password    | The login process ended because the user failed to enter a correct password after three attempts. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                                                                    | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1026 – TS No TCP Raw      | The raw TCP option is not enabled. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                                                                                                                                   | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1027 – TS CNTL-C          | The login process ended because the user typed Ctrl-C. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                                                                                                               | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1028 – TS Session End     | The terminal server session has ended. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                                                                                                                               | no   | no   | no   | no   | yes  | yes  | yes  | yes  |



| Cause Codes                  | Description                                                                                                                                                                      | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 | 12.3 |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|
| 1029 – TS Close Vconn        | The user closed the virtual connection. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                                       | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1030 – TS End Vconn          | The virtual connection has ended. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                                             | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1031 – TS Rlogin Exit        | The user exited normally from an Rlogin session. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                              | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1032 – TS Rlogin Opt Invalid | The user selected an invalid Rlogin option. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.                                   | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1033 – TS Insuff Resources   | The access server has insufficient resources for the terminal server session. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session. | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1040 – PPP LCP Timeout       | PPP link control protocol (LCP) negotiation timed out while waiting for a response from a peer. This code concerns PPP connections.                                              | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1041 – PPP LCP Fail          | There was a failure to converge on PPP LCP negotiations. This code concerns PPP connections.                                                                                     | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1042 – PPP Pap Fail          | PPP Password Authentication Protocol (PAP) authentication failed. This code concerns PPP connections.                                                                            | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1043 – PPP CHAP Fail         | PPP Challenge Handshake Authentication Protocol (CHAP) authentication failed. This code concerns PPP connections.                                                                | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1044 – PPP Remote Fail       | Authentication failed from the remote server. This code concerns PPP sessions.                                                                                                   | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1045 – PPP Receive Term      | The peer sent a PPP termination request. This code concerns PPP connections.                                                                                                     | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| PPP LCP Close (1046)         | LCP got a close request from the upper layer while LCP was in an open state. This code concerns PPP connections.                                                                 | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1047 – PPP No NCP            | LCP closed because no NCPs were open. This code concerns PPP connections.                                                                                                        | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1048 – PPP MP Error          | LCP closed because it could not determine to which Multilink PPP bundle that it should add the user. This code concerns PPP connections.                                         | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1049 – PPP Max Channels      | LCP closed because the access server could not add any more channels to an MP session. This code concerns PPP connections.                                                       | no   | no   | no   | no   | yes  | yes  | yes  | yes  |

| Cause Codes                      | Description                                                                                                                                                                                                               | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 | 12.3 |
|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|
| 1050 – TS Tables Full            | The raw TCP or Telnet internal session tables are full. This code relates to immediate Telnet and raw TCP disconnects and contains more specific information than the Telnet and TCP codes listed earlier in this table.  | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1051 – TS Resource Full          | Internal resources are full. This code relates to immediate Telnet and raw TCP disconnects and contains more specific information than the Telnet and TCP codes listed earlier in this table.                             | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1052 – TS Invalid IP Addr        | The IP address for the Telnet host is invalid. This code relates to immediate Telnet and raw TCP disconnects and contains more specific information than the Telnet and TCP codes listed earlier in this table.           | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1053 – TS Bad Hostname           | The access server could not resolve the host name. This code relates to immediate Telnet and raw TCP disconnects and contains more specific information than the Telnet and TCP codes listed earlier in this table.       | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1054 – TS Bad Port               | The access server detected a bad or missing port number. This code relates to immediate Telnet and raw TCP disconnects and contains more specific information than the Telnet and TCP codes listed earlier in this table. | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1060 – TCP Reset                 | The host reset the TCP connection. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.                                                                                           | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1061 – TCP Connection Refused    | The host refused the TCP connection. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.                                                                                         | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1062 – TCP Timeout               | The TCP connection timed out. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.                                                                                                | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1063 – TCP Foreign Host Close    | A foreign host closed the TCP connection. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.                                                                                    | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1064 – TCP Net Unreachable       | The TCP network was unreachable. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.                                                                                             | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1065 – TCP Host Unreachable      | The TCP host was unreachable. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.                                                                                                | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1066 – TCP Net Admin Unreachable | The TCP network was administratively unreachable. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.                                                                            | no   | no   | no   | no   | yes  | yes  | yes  | yes  |

| Cause Codes                       | Description                                                                                                                                                      | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 | 12.3 |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|
| 1067 – TCP Host Admin Unreachable | The TCP host was administratively unreachable. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.                      | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1068 – TCP Port Unreachable       | The TCP port was unreachable. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.                                       | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1100 – Session Timeout            | The session timed out because there was no activity on a PPP link. This code applies to all session types.                                                       | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1101 – Security Fail              | The session failed for security reasons. This code applies to all session types.                                                                                 | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1102 – Callback                   | The session ended for callback. This code applies to all session types.                                                                                          | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1120 – Unsupported                | One end refused the call because the protocol was disabled or unsupported. This code applies to all session types.                                               | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1150 – Radius Disc                | The RADIUS server requested the disconnect.                                                                                                                      | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1151 – Local Admin Disc           | The local administrator has disconnected.                                                                                                                        | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1152 – SNMP Disc                  | Simple Network Management Protocol (SNMP) has disconnected.                                                                                                      | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1160 – V110 Retries               | The allowed retries for V110 synchronization have been exceeded.                                                                                                 | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1170 – PPP Auth Timeout           | Authentication timeout. This code applies to PPP sessions.                                                                                                       | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1180 – Local Hangup               | The call disconnected as the result of a local hangup.                                                                                                           | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1185 – Remote Hangup              | The call disconnected because the remote end hung up.                                                                                                            | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1190 – T1 Quiesced                | The call disconnected because the T1 line that carried it was quiesced.                                                                                          | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1195 – Call Duration              | The call disconnected because the call duration exceeded the maximum amount of time allowed by the Max Call Mins or Max DS0 Mins parameter on the access server. | no   | no   | no   | no   | yes  | yes  | yes  | yes  |
| 1600 – VPDN User Disconnect       | The user disconnected. This value applies to virtual private dial-up network (VPDN) sessions.                                                                    | no   | no   | no   | no   | no   | no   | yes  | yes  |
| 1601 – VPDN Carrier Loss          | Carrier loss has occurred. This code applies to VPDN sessions.                                                                                                   | no   | no   | no   | no   | no   | no   | yes  | yes  |
| 1602 – VPDN No Resources          | There are no resources. This code applies to VPDN sessions.                                                                                                      | no   | no   | no   | no   | no   | no   | yes  | yes  |
| 1603 – VPDN Bad Control Packet    | The control packet is invalid. This code applies to VPDN sessions.                                                                                               | no   | no   | no   | no   | no   | no   | yes  | yes  |

| Cause Codes                         | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 | 12.3 |
|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|
| 1604 – VPDN Admin Disconnect        | The administrator disconnected. This code applies to VPDN sessions.                                                                                                                                                                                                                                                                                                                                                                                                          | no   | no   | no   | no   | no   | no   | yes  | yes  |
| 1605 – VPDN Tunnel Down/Setup Fail  | The tunnel is down or the setup failed. This code applies to VPDN sessions.                                                                                                                                                                                                                                                                                                                                                                                                  | no   | no   | no   | no   | no   | no   | yes  | yes  |
| 1606 – VPDN Local PPP Disconnect    | There was a local PPP disconnect. This code applies to VPDN sessions.                                                                                                                                                                                                                                                                                                                                                                                                        | no   | no   | no   | no   | no   | no   | yes  | yes  |
| 1607 – VPDN Softshut/Session Limit  | New sessions cannot be established on the VPN tunnel. This code applies to VPDN sessions.                                                                                                                                                                                                                                                                                                                                                                                    | no   | no   | no   | no   | no   | no   | yes  | yes  |
| 1608 – VPDN Call Redirected         | The call was redirected. This code applies to VPDN sessions.                                                                                                                                                                                                                                                                                                                                                                                                                 | no   | no   | no   | no   | no   | no   | yes  | yes  |
| 1801 – Q850 Unassigned Number       | The number has not been assigned. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                                                                                                                                                                                                                                           | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1802 – Q850 No Route                | The equipment that is sending this code has received a request to route the call through a particular transit network that it does not recognize. The equipment that is sending this code does not recognize the transit network because either the transit network does not exist or because that particular transit network, while it does exist, does not serve the equipment that is sending this code. This code applies to ISDN or modem calls that came in over ISDN. | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1803 – Q850 No Route To Destination | The called party cannot be reached because the network through which the call has been routed does not serve the destination that is desired. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                                                                                                                               | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1806 – Q850 Channel Unacceptable    | The channel that has been most recently identified is not acceptable to the sending entity for use in this call. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                                                                                                                                                            | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1816 – Q850 Normal Clearing         | The call is being cleared because one of the users who is involved in the call has requested that the call be cleared. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                                                                                                                                                      | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1817 – Q850 User Busy               | The called party is unable to accept another call because the user-busy condition has been encountered. This code may be generated by the called user or by the network. In the case of the user, the user equipment is compatible with the call. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                           | no   | no   | no   | no   | no   | no   | no   | yes  |

| Cause Codes                              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 | 12.3 |
|------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|
| 1818 – Q850 No User Responding           | Used when a called party does not respond to a call-establishment message with either an alerting or connect indication within the prescribed period of time that was allocated. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                                                                                                                                       | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1819 – Q850 No User Answer               | The called party has been alerted but does not respond with a connect indication within a prescribed period of time. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                                                                                                                                                                                                   | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1821 – Q850 Call Rejected                | The equipment that is sending this code does not wish to accept this call although it could have accepted the call because the equipment that is sending this code is neither busy nor incompatible. This code may also be generated by the network, indicating that the call was cleared due to a supplementary service constraint. The diagnostic field may contain additional information about the supplementary service and reason for rejection. This code applies to ISDN or modem calls that came in over ISDN. | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1822 – Q850 Number Changed               | The number that is indicated for the called party is no longer assigned. The new called party number may optionally be included in the diagnostic field. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                                                                                                                                                               | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1827 – Q850 Destination Out of Order     | The destination that was indicated by the user cannot be reached because the interface to the destination is not functioning correctly. The term “not functioning correctly” indicates that a signaling message was unable to be delivered to the remote party. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                                                        | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1828 – Q850 Invalid Number Format        | The called party cannot be reached because the called party number is not in a valid format or is not complete. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                                                                                                                                                                                                        | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1829 – Q850 Facility Rejected            | This code is returned when a supplementary service that was requested by the user cannot be provided by the network. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                                                                                                                                                                                                                                              | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1830 – Q850 Responding to Status Enquiry | This code is included in the STATUS message when the reason for generating the STATUS message was the prior receipt of a STATUS ENQUIRY message. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                                                                                                                                                                       | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1831 – Q850 Unspecified Cause            | No other code applies. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                                                                                                                                                                                                                                                                                                                 | no   | no   | no   | no   | no   | no   | no   | yes  |

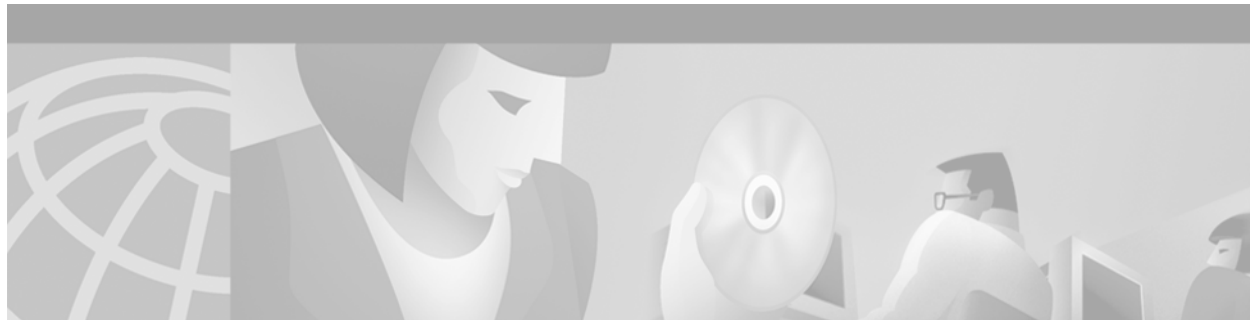
| Cause Codes                                 | Description                                                                                                                                                                                                                  | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 | 12.3 |
|---------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|
| 1834 – Q850 No Circuit Available            | No circuit or channel is available to handle the call. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                      | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1838 – Q850 Network Out of Order            | The network is not functioning correctly and the condition is likely to last a relatively long period of time. This code applies to ISDN or modem calls that came in over ISDN.                                              | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1841 – Q850 Temporary Failure               | The network is not functioning correctly and the condition is not likely to last a long period of time. This code applies to ISDN or modem calls that came in over ISDN.                                                     | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1842 – Q850 Network Congestion              | The network is congested. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                   | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1843 – Q850 Access Info Discarded           | This code indicates that the network could not deliver access information to the remote user as requested. This code applies to ISDN or modem calls that came in over ISDN.                                                  | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1844 – Q850 Requested Channel Not Available | This code is returned when the circuit or channel that is indicated by the requesting entity cannot be provided by the other side of the interface. This code applies to ISDN or modem calls that came in over ISDN.         | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1845 – Q850 Call Pre-empted                 | The call was preempted. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                     | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1847 – Q850 Resource Unavailable            | This code is used to report a resource-unavailable event only when no other code in the resource-unavailable class applies. This code applies to ISDN or modem calls that came in over ISDN.                                 | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1850 – Q850 Facility Not Subscribed         | Not a subscribed facility. This code applies to ISDN or modem calls that came in over ISDN.                                                                                                                                  | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1852 – Q850 Outgoing Call Barred            | Although the calling party is a member of the closed user group for the outgoing closed user group call, outgoing calls are not allowed for this member. This code applies to ISDN or modem calls that came in over ISDN.    | no   | no   | no   | no   | no   | no   | no   | yes  |
| Q850 Incoming Call Barred (1854)            | Although the called party is a member of the closed user group for the incoming closed user group call, incoming calls are not allowed to this member. This code applies to ISDN or modem calls that have come in over ISDN. | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1858 – Q850 Bearer Capability Not Available | The user has requested a bearer capability that is implemented by the equipment that generated this code but that is not available at this time. This code applies to ISDN or modem calls that have come in over ISDN.       | no   | no   | no   | no   | no   | no   | no   | yes  |

| Cause Codes                                   | Description                                                                                                                                                                                                                                                                                                                 | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 | 12.3 |
|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|
| 1863 – Q850 Service Not Available             | The code is used to report a service- or option-not-available event only when no other code in the service- or option-not-available class applies. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                    | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1865 – Q850 Bearer Capability Not Implemented | The equipment that is sending this code does not support the bearer capability that was requested. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                                                                    | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1866 – Q850 Channel Not Implemented           | The equipment that is sending this code does not support the channel type that was requested. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                                                                         | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1869 – Q850 Facility Not Implemented          | The supplementary service requested by the user cannot be provided by the network. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                                                                                    | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1881 – Q850 Invalid Call Reference            | The equipment that is sending this code has received a message having a call reference that is not currently in use on the user-network interface. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                    | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1882 – Q850 Channel Does Not Exist            | The channel most recently identified is not acceptable to the sending entity for use in this call. This code applies to ISDN or modem calls that have come in over ISDN. This code applies to ISDN or modem calls that have come in over ISDN.                                                                              | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1888 – Q850 Incompatible Destination          | The equipment that is sending this code has received a request to establish a call that has low-layer compatibility or other compatibility attributes that cannot be accommodated. This code applies to ISDN or modem calls that have come in over ISDN.                                                                    | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1896 – Q850 Mandatory Info Element Is Missing | The equipment that is sending this code has received a message that is missing an information element that must be present in the message before that message can be processed. This code applies to ISDN or modem calls that have come in over ISDN.                                                                       | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1897 – Q850 Non Existent Message Type         | The equipment that is sending this code has received a message with a message type that it does not recognize either because this is a message that is not defined or that is defined but not implemented by the equipment that is sending this code. This code applies to ISDN or modem calls that have come in over ISDN. | no   | no   | no   | no   | no   | no   | no   | yes  |

| Cause Codes                                   | Description                                                                                                                                                                                                                                                                                                                                                                 | 11.0 | 11.1 | 11.2 | 11.3 | 12.0 | 12.1 | 12.2 | 12.3 |
|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|
| 1898 – Q850 Invalid Message                   | This code is used to report an invalid message when no other code in the invalid message class applies. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                                                                                                               | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1899 – Q850 Bad Info Element                  | The information element not recognized. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                                                                                                                                                                               | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1900 – Q850 Invalid Element Contents          | The equipment that is sending this code has received an information element that it has implemented; however, one or more fields in the information element are coded in such a way that has not been implemented by the equipment that is sending this code. This code applies to ISDN or modem calls that have come in over ISDN.                                         | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1901 – Q850 Wrong Message for State           | The message that was received is incompatible with the call state. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                                                                                                                                                    | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1902 – Q850 Recovery on Timer Expiration      | A procedure has been initiated by the expiration of a timer in association with error-handling procedures. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                                                                                                            | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1903 – Q850 Info Element Error                | The equipment that is sending this code has received a message that includes information elements or parameters that are not recognized because the information element identifiers or parameter names are not defined or are defined but not implemented by the equipment that is sending this code. This code applies to ISDN or modem calls that have come in over ISDN. | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1911 – Q850 Protocol Error                    | This code is used to report a protocol error event only when no other code in the protocol error class applies. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                                                                                                       | no   | no   | no   | no   | no   | no   | no   | yes  |
| 1927 – Q850 Unspecified Internetworking Event | There has been an error when interworking with a network that does not provide codes for actions that it takes. This code applies to ISDN or modem calls that have come in over ISDN.                                                                                                                                                                                       | no   | no   | no   | no   | no   | no   | no   | yes  |

For more information about configuring TACACS+ accounting, refer to the chapter “[Configuring Accounting](#).”





# Installation and Configuration for Common Criteria EAL4 Evaluated Cisco IOS IPSec

---

July 2002 (version 1.0)

## Contents

This document describes how to install and configure Cisco IOS routers in accordance with the Common Criteria Evaluation Assurance Level 4 (EAL4) evaluated Cisco IOS IP Security (IPSec).



### Note

---

Any changes to the information provided in this document will result in noncompliance between the Cisco IOS router and the Cisco IOS IPSec evaluation and may make the router insecure.

---

This document includes the following sections:

- [Introduction, page 2](#)
- [Audience, page 2](#)
- [Supported Hardware and Software, page 2](#)
- [Security Information, page 3](#)
- [Installation Notes, page 8](#)
- [Configuration Notes, page 11](#)
- [Hardware Versions of Hardware IPSec VPN Modules, page 14](#)
- [MD5 Hash Values for Cisco IOS Software Images, page 15](#)
- [Related Documentation, page 19](#)
- [Obtaining Documentation, page 19](#)
- [Obtaining Technical Assistance, page 20](#)



---

### Corporate Headquarters:

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

Copyright © 2002. Cisco Systems, Inc. All rights reserved.

# Introduction

This document is an addendum to the Cisco IOS Release 12.1 and Release 12.2 documentation sets, which should be read prior to configuring a Cisco IOS router in accordance with the Common Criteria EAL4 evaluated Cisco IOS IPSec.

The Cisco IOS Release 12.1 and Release 12.2 documentation sets include the following elements:

- Configuration guides, which provide a descriptive overview of functions, the commands needed to enable specified functions, and the sequence of operations that should be followed to implement them.
- Command references, which provide a complete description of all configuration commands and options, their effects, and examples and guidelines for the use of the commands. The command references should be used to confirm detailed syntax and functionality options.
- System Error Messages, which describe all error messages issued by Cisco IOS routers.

This document references the following Cisco IOS Release 12.1 and Release 12.2 documentation:

- *Cisco IOS Configuration Fundamentals Configuration Guide*
- *Cisco IOS Configuration Fundamentals Command Reference*
- *Cisco IOS Security Configuration Guide*
- *Cisco IOS Security Command Reference*
- *Cisco IOS IP Configuration Guide*
- *Cisco IOS IP Command Reference, Volume 1 of 3: Addressing and Services*
- *Cisco IOS IP Command Reference, Volume 2 of 3: Routing Protocols*
- *Cisco IOS System Error Messages*
- Release Notes and Caveats for Cisco IOS Release 12.2

Cisco IOS documentation is available on CD-ROM, in printed paper form, and online (in HTML and PDF formats). This document should be used in conjunction with the October 2001 edition of the CD-ROM-based documentation.

## Audience

This document is written for administrators who configure Cisco IOS routers in accordance with the Common Criteria evaluated Cisco IOS IPSec. This document assumes that you are familiar with networks and networking technology, are a trusted individual, and been trained to use the IPSec technology and its applications, such as site-to-site Virtual Private Networks (VPNs). There are no components of the Cisco IOS IPSec that are accessible to nonadministrative users (end users); therefore, there is not any user-level documentation.

## Supported Hardware and Software

The hardware and software combinations that are compliant with Common Criteria evaluated Cisco IOS IPSec are outlined in [Table 1](#). (The supporting hardware documentation is outlined in [Table 2](#).)

**Note**

Only the hardware versions of the IPSec VPN hardware modules that are listed in [Table 8](#) are compliant with Common Criteria evaluated Cisco IOS IPSec. To display the hardware version of an IPSec VPN hardware module, use the **show diag** command in privileged EXEC mode.

**Table 1**      *Supported Hardware and Software for the Common Criteria Evaluated Cisco IOS IPSec*

| Hardware Family                | Supported Models                                   | Optional IPSec VPN Hardware Module         | Software Versions   | Software Feature                    |
|--------------------------------|----------------------------------------------------|--------------------------------------------|---------------------|-------------------------------------|
| Cisco 1700 series              | 1720, 1750                                         | MOD1700-VPN                                | Cisco IOS 12.2(6)   | IPSec 56<br>IPSec 3DES <sup>1</sup> |
| Cisco 2600 series              | 2610, 2611, 2612, 2613, 2620, 2621, 2650, and 2651 | AIM-VPN/BP                                 | Cisco IOS 12.2(6)   | IPSec 56<br>IPSec 3DES <sup>1</sup> |
| Cisco 3600 series              | 3620, 3640                                         | NM-VPN/MP                                  | Cisco IOS 12.2(6)   | IPSec 56<br>IPSec 3DES <sup>1</sup> |
|                                | 3660                                               | AIM-VPN/HP                                 | Cisco IOS 12.2(6)   | IPSec 56<br>IPSec 3DES <sup>1</sup> |
| Cisco 7100 series <sup>2</sup> | 7120, 7140                                         | SA-ISA or SM-ISM                           | Cisco IOS 12.2(6)   | IPSec 56<br>IPSec 3DES <sup>1</sup> |
|                                |                                                    | SM-VAM <sup>3</sup> or SA-VAM <sup>3</sup> | Cisco IOS 12.1(10)E | IPSec 56<br>IPSec 3DES <sup>1</sup> |
| Cisco 7200 series              | 7204, 7206, 7204VXR, 7206VXR                       | SA-ISA (max 2)                             | Cisco IOS 12.2(6)   | IPSec 56<br>IPSec 3DES <sup>1</sup> |
|                                |                                                    | SA-VAM <sup>3</sup>                        | Cisco IOS 12.1(10)E | IPSec 56<br>IPSec 3DES <sup>1</sup> |

1. The Cisco IOS software image must contain at least the IPSec 56 or IPSec 3DES feature, which can be in combination with other feature sets such as IP, Firewall, Plus, or Enterprise.
2. The Cisco 7100 series and Cisco 7200 series without optional IPSec hardware acceleration modules can be configured with Cisco IOS Release 12.2(6)T or Cisco IOS Release 12.1(10)E.
3. Cisco 7100 series and Cisco 7200 series that are equipped with an SA-VAM or SM-VAM do not support Rivest, Shamir, and Adelman (RSA) public or private key pairs for IKE authentication.

## Security Information

This section contains the following sections:

- [Supported Hardware Documentation](#)
- [Organizational Security Policy](#)
- [Security Implementation Considerations](#)

## Supported Hardware Documentation

In addition to the regulatory compliance documentation for each hardware platform listed in [Table 2](#), the sections that follow provide additional security information for use with a Common Criteria evaluation Cisco IOS IPSec router.

**Table 2** *Regulatory Compliance and Safety Information Documentation for Common Criteria Evaluated Cisco IOS IPSec Hardware Platforms*

| Hardware Family   | Regulatory Compliance and Safety Information Documentation                            |
|-------------------|---------------------------------------------------------------------------------------|
| Cisco 1700 series | <i>Regulatory Compliance and Safety Information for Cisco 1700 Series Routers</i>     |
| Cisco 2600 series | <i>Regulatory Compliance and Safety Information for the Cisco 2600 Series Routers</i> |
| Cisco 3600 series | <i>Regulatory Compliance and Safety Information for the Cisco 3600 Series Routers</i> |
| Cisco 7100 series | <i>Regulatory Compliance and Safety Information for Cisco 7100 Series VPN Routers</i> |
| Cisco 7200 series | <i>Regulatory Compliance and Safety Information for Cisco 7200 Series Routers</i>     |

## Organizational Security Policy

Ensure that your Cisco IOS router is delivered, installed, managed, and operated in a manner that maintains an organizational security policy for IPSec protected traffic. The organizational security policy *must* describe the following variables:

- The networks that are to be considered trusted and untrusted
- The traffic flows between trusted networks that must be protected using IPSec to provide confidentiality, authenticity, and integrity in terms of source and destination IP addresses or port number
- The Cisco IOS routers that are associated with each trusted network that provide IPSec services to the identified traffic flows

The administrator must identify which interfaces on the Cisco IOS router are considered trusted and untrusted. An untrusted interface is one that is connected to an untrusted network over which the administrator wishes to send and receive trusted traffic that is protected by IPSec encryption.

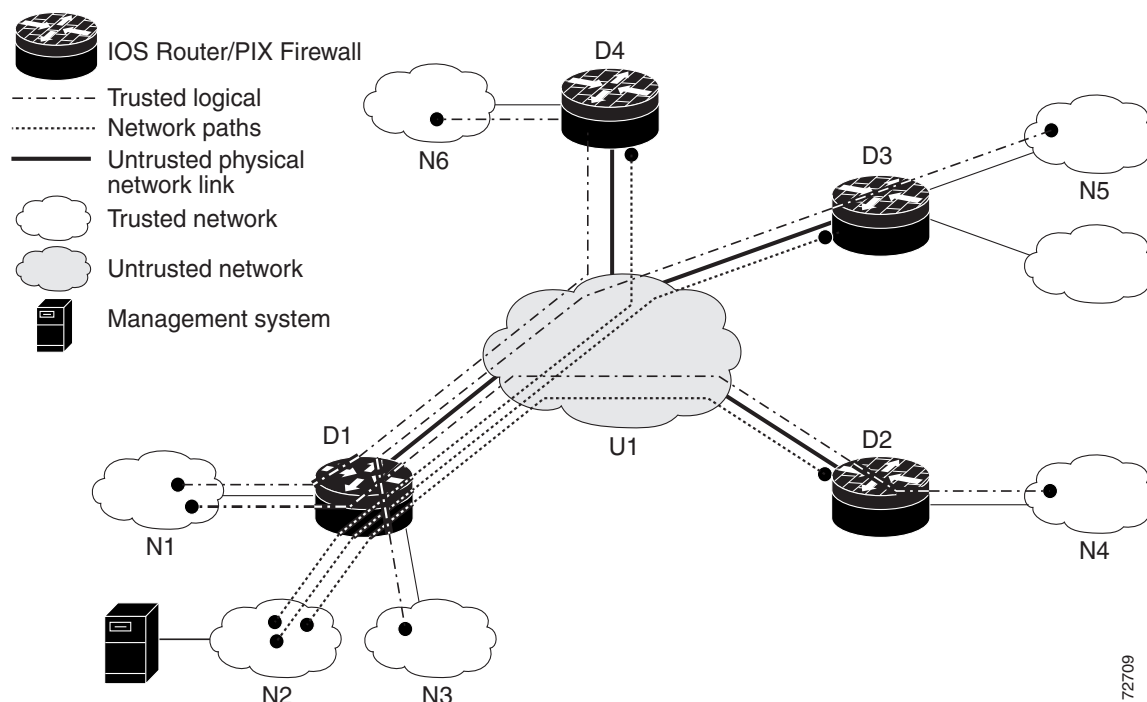
**Figure 1** Organizational Security Policy Example

Figure 1 displays an organizational security policy with traffic flows that are identified solely by source and destination IP addresses. All Cisco IOS routers (D1, D2, D3, and D4) must be configured to implement a portion of the organizational security policy. For example, Router D1 has three trusted networks attached to it (N1, N2, and N3); this router implements a policy for the three trusted network-to-network flows and three secure management flows that cross the untrusted network (U1). (The policy that Router D1 implements is outlined in Table 3.)

**Table 3** Policy for Cisco IPSec Crypto System Example

| Source | Destination | Peer Device |
|--------|-------------|-------------|
| N1     | N6          | D4          |
| N1     | N5          | D3          |
| N3     | N4          | D2          |
| N2     | D2          | D2          |
| N2     | D3          | D3          |
| N2     | D4          | D4          |

All other routers (D2, D3, D4) must have a matching configuration to implement the organizational security policy. Each of the rows in Table 3 is configured on the Cisco IOS router as an IPSec tunnel.

An organizational security policy may implement a site-to-site VPN between multiple locations (trusted networks) over the Internet (an untrusted network), or it may specify that all LAN traffic (trusted networks) be encrypted when transmitted over any WAN link (untrusted network).

## Security Implementation Considerations

The following sections provide implementation considerations that need to be addressed to administer Cisco IOS routers in a secure manner that is consistent with Common Criteria evaluated Cisco IOS IPsec:

- [Evaluated Configuration](#)
- [Physical Security](#)
- [Certificate Authority](#)
- [Time Sources](#)
- [Access Control](#)
- [Remote Administration and Management](#)
- [SNMP](#)
- [Logging and Messages](#)
- [Access Lists](#)
- [Monitoring and Maintenance](#)

### Evaluated Configuration

Only the hardware and software version combinations that are described in [Table 1](#) can be used to implement an evaluated configuration. You will invalidate the evaluated status of a particular hardware platform if you change the software to a different version.

The Common Criteria Target of Evaluation (TOE) for Cisco IOS IPsec defines only the following features:

- IPsec Internet Key Exchange (IKE) using preshared keys, RSA keys, or digital certificates




---

**Note** The Cisco 7100 series and Cisco 7200 series with an SM-VAM or SA-VAM do not support IKE with RSA keys.

---

- IPsec encapsulating security payload (ESP) using tunnel mode with Data Encryption Standard (DES) or 3DES
- Optional hardware acceleration of IPsec (as specified in [Table 1](#))
- Cryptographic key generation and management
- Inbound access lists
- Message logging
- User authentication for access to the command-line interface (CLI) using locally configured passwords




---

**Note** Although Cisco IOS supports authentication, authorization, and accounting (AAA) user authentication, it is not supported within the Cisco IOS-IPsec TOE.

---

- Time management

All other hardware and software features and functions of a Cisco IOS router are outside the scope of this evaluated product configuration, and therefore can be used in conjunction with the TOE functions only if the TOE functions are configured, operated, and managed in accordance with this document.

To ensure that the Cisco IOS router configuration continues to meet the organizational security policy, you should review your router configurations for the following possible changes:

- Changes in the Cisco IOS router configuration
- Changes in the organizational security policy
- Changes in the threats presented from untrusted networks
- Changes in the administration and operation staff or of the physical environment of the Cisco IOS router

## Physical Security

The Cisco IOS router must be located in a physically secure environment in which only a trusted administrator has access. The secure configuration of a Cisco IOS router can be compromised if an intruder gains physical access to the router.

## Certificate Authority

If digital certificates are used to provide authentication between evaluated Cisco IOS IPSec routers, the certificate authority that issues the certificates must be trusted or evaluated to the same level as Cisco IOS IPSec (Common Criteria EAL4).

## Time Sources

Routers configured in accordance with the Cisco IOS IPSec evaluation must time-stamp system log messages. For Cisco routers without internal, real-time hardware clocks (Cisco 1700, 2600, 3600 series), their software clock must be set from an external time source via the Network Time Protocol (NTP). To provide a trusted time source for the TOE, NTP servers must be connected to a trusted network in a secure location.

## Access Control

The Cisco IOS router must be configured to authenticate privileged (enable mode) and unprivileged access to the CLI using a username or password. A good password has a combination of alphabetic and numeric characters, as well as punctuation characters. This password must be at least eight characters in length. We recommend that you tell the password to someone who is in a position of trust.

## Remote Administration and Management

If you administer and manage the Cisco IOS router from a remote management system across an untrusted network, the following requirements apply:

- The management station must be connected to a trusted network.
- There must be another Cisco IOS router connected to the trusted and untrusted network.
- There must be an IPSec tunnel between the trusted network and the Cisco IOS router that is managed.

A topology such as [Figure 1](#), which displays these requirements, applies to any in-band administrative protocol including Telnet, Simple Network Management Protocol (SNMP), and syslog.

## SNMP

If SNMP read-write access is permitted, the TOE operation can be modified via SNMP. Therefore, SNMP must be configured explicitly in read-only mode if it is enabled on the TOE to support monitoring of the Cisco IOS router.

## Logging and Messages

Monitoring activity in the log files is an important aspect of your network security and should be conducted regularly. Monitoring the log files allows you take appropriate and timely action when you detect breaches of security or events that are likely to lead to a potential security breach.

To view log file messages, use the **show logging** EXEC command. For configuration details, refer to the section “Message Logging” in [Table 6](#).

## Access Lists

The **access-list** command operates on a first match basis. Thus, the last rule added to the access list is the last rule checked. The administrator should make a note of the last rule during initial configuration because it may impact the remainder of the rule parsing.

To enable logging of access-list matches, use the **log** keyword with access-list definitions.

## Monitoring and Maintenance

There are several ways (from logs to messages) in which you can monitor the operation of your Cisco IOS routers. However, ensure you know how you will monitor the router for performance and possible security issues. Also, plan your backups; if there should be hardware or software problems, you may need to restore the router configuration.

# Installation Notes

[Table 4](#) lists the documentation that should be used when installing a Cisco IOS IPSec evaluated router.

**Table 4**      *Installation Documentation for Cisco IOS IPSec Hardware Platforms*

| Hardware Family   | Regulatory Compliance and Safety Information Documentation                                                |
|-------------------|-----------------------------------------------------------------------------------------------------------|
| Cisco 1700 series | <i>Cisco 1720 Series Router Hardware Installation Guide</i>                                               |
|                   | <i>Cisco 1750 Series Router Hardware Installation Guide</i>                                               |
|                   | <i>Installing the Data Encryption AIM in Cisco 1700 Series Routers</i> <sup>1</sup>                       |
| Cisco 2600 series | <i>Cisco 2600 Series Hardware Installation Guide</i>                                                      |
|                   | <i>Installing the Data Encryption AIM in Cisco 2600 Series and Cisco 3600 Series Routers</i> <sup>1</sup> |



**Table 4**     *Installation Documentation for Cisco IOS IPSec Hardware Platforms (continued)*

| Hardware Family   | Regulatory Compliance and Safety Information Documentation                                                                                                                                                                                                                                                                                                                  |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cisco 3600 series | <i>Cisco 3600 Series Hardware Installation Guide</i><br><i>Installing the Data Encryption AIM in Cisco 2600 Series and Cisco 3600 Series Routers</i> <sup>1</sup>                                                                                                                                                                                                           |
| Cisco 7100 series | <i>Cisco 7100 Series VPN Router Installation and Configuration Guide</i><br><i>Integrated Service Adapter and Integrated Service Module Installation and Configuration</i> <sup>1</sup><br><i>VPN Acceleration Module Installation and Configuration</i> <sup>1</sup>                                                                                                       |
| Cisco 7200 series | <i>Cisco 7204 Installation and Configuration Guide</i><br><i>Cisco 7206 Installation and Configuration Guide</i><br><i>Cisco 7200 VXR Installation and Configuration Guide</i><br><i>Integrated Service Adapter and Integrated Service Module Installation and Configuration</i> <sup>1</sup><br><i>VPN Acceleration Module Installation and Configuration</i> <sup>1</sup> |

1. Hardware encryption acceleration modules are optional.

## Verification of Image and Hardware IPSec Module

To verify that the Cisco IOS software and hardware IPSec VPN module (if used) has not been tampered with during delivery, perform the following steps.



### Note

If a hardware IPSec VPN module is not being used, only steps 6 and 7 are necessary.



### Note

Hardware IPSec VPN modules are delivered either as separate discrete items or preinstalled in a Cisco router platform.

- Step 1**     Inspect the physical packaging in which the equipment was delivered before unpacking the hardware IPSec VPN module.
- Verify that the external cardboard packing is printed with the Cisco Systems logo and motifs. If the external packaging is not printed with Cisco branding, contact the equipment supplier (Cisco Systems or an authorized Cisco distributor or partner).
- Step 2**     Verify that the packaging has not been opened and resealed by examining the tape that seals the package. If the package appears to have been resealed, contact the equipment supplier.
- Step 3**     Verify that the box has a white tamper-resistant, tamper-evident Cisco Systems bar-coded label that is applied to the external cardboard box. (This label will include the Cisco product number, serial number, and other information regarding the contents of the box.) If this label is missing, contact the equipment supplier.
- Step 4**     Note the serial number of the hardware IPSec VPN module on the shipping documentation. If the hardware IPSec VPN module has been preinstalled, the white label on the outer box will show the serial number of the router platform inside; thus, the serial number of the hardware IPSec VPN module will appear on the shipping documents also attached to the outer box. Otherwise, if the VPN has not been

preinstalled, the serial number of the hardware IPsec VPN module will be displayed on the white label.

Ensure that the serial number on the shipping documentation matches the serial number on the separately mailed invoice for the equipment. If the serial numbers do not match, contact the equipment supplier.

**Step 5** Verify that the box has been shipped from the expected equipment supplier by performing the following tasks:

- Contact the supplier to verify that the box was shipped with the courier company that delivered the box and that the consignment note number for the shipment matches the number used for the delivery.
- Verify that the serial numbers of the items shipped match the serial numbers of the items delivered. For equipment shipped directly from Cisco, you can verify the serial numbers online through Cisco's Networking Products Marketplace, Order Status Tool. For other suppliers, verify that the serial numbers match by using a mechanism that was not involved in the actual equipment delivery; for example, use the phone, fax, or another online tracking service.

**Step 6** Inspect the module after the hardware IPsec VPN module has been unpacked. Verify that the serial number displayed on the module matches the serial number on the shipping documentation and the invoice. If the serial numbers do not match, contact the equipment supplier.

**Step 7** Download a Common Criteria evaluated software image file from Cisco Connection Online (CCO) for your specific hardware platform onto a trusted computer system (as specified in [Table 1](#)). For all images, ensure that you have sufficient system and Flash memory to support the image on your router hardware by checking the release notes appropriate for the Cisco IOS release and by selecting the IPsec 56 or IPsec 3DES feature set.

Software images for Release 12.2(6) are available from CCO at the following URL:

<http://cco.cisco.com/kobayashi/library/12.2/index.shtml>

Software images for Release 12.1(10)E available from CCO at the following URL:

<http://cco.cisco.com/kobayashi/library/12.1/index.shtml>

After you have downloaded the file, verify that the file has not been tampered with by using a Message Digest 5 (MD5) utility to compute an MD5 hash for the file; compare this MD5 hash with the MD5 hash for the image, which is listed in [Table 9](#). If the MD5 hashes do not match, contact Cisco Technical Support.

**Step 8** Install the downloaded and verified software image onto your Cisco IOS router. For information on completing this task, refer to the chapter "Loading and Maintaining System Images" in the part "File Management" of the *Cisco IOS Configuration Fundamentals Configuration Guide*.

**Step 9** Start your router as described in the appropriate installation documentation that is outlined in [Table 4](#). Confirm that your router loads the image correctly, completes internal self-checks, and displays the cryptographic export warning on the console. At the prompt, type the **show version** command. (See [Figure 2](#).) Verify that the version matches one of the valid versions listed in [Table 1](#). If the versions do not match or if the image fails to load, contact Cisco Technical Support.

**Step 10** If the hardware IPsec VPN module has not been preinstalled, refer to one of the installation guides in [Table 4](#).

**Step 11** After the IPsec VPN module is installed, restart the router. At the prompt, enter the **show version** command. (See [Figure 2](#).) To verify that a VPN module is installed, read the output display. If the output display does not report that the hardware IPsec VPN module is present, contact Cisco Technical Support.

- Step 12** Enter the **show diag** command. Examine the output to ensure that the serial number reported by the hardware IPsec VPN module is the same as the serial number on the shipping documentation, invoice, and the hardware IPsec VPN module itself. Also, verify that the hardware version and revision of the module are listed in [Table 8](#).

**Figure 2** Sample show version Output That Shows the Cisco IOS Version and Presence of the Hardware IPsec VPN Module

```
Router>show version
Cisco Internetwork Operating System Software
IOS (tm) 3600 Software (C3620-IK9S-M), Version 12.2(6), RELEASE SOFTWARE (fc2)
Copyright (c) 1986-2001 by cisco Systems, Inc.
Compiled Thu 08-Nov-01 03:32 by pwade
Image text-base: 0x600089A8, data-base: 0x61302000

ROM: System Bootstrap, Version 11.1(17)AA, EARLY DEPLOYMENT RELEASE SOFTWARE (f)

Router uptime is 13 minutes
System returned to ROM by power-on
System image file is "slot0:c3620-ik9s-mz.122-6.bin"

cisco 3620 (R4700) processor (revision 0x81) with 61440K/4096K bytes of memory.
Processor board ID 07655126
R4700 CPU at 80Mhz, Implementation 33, Rev 1.0
Bridging software.
X.25 software, Version 3.0.0.
SuperLAT software (copyright 1990 by Meridian Technology Corp).
4 Ethernet/IEEE 802.3 interface(s)
1 Virtual Private Network (VPN) Module(s)
DRAM configuration is 32 bits wide with parity disabled.
29K bytes of non-volatile configuration memory.
8192K bytes of processor board System flash (Read/Write)
16384K bytes of processor board PCMCIA Slot0 flash (Read/Write)

Configuration register is 0x2102
```

72710

## Configuration Notes

The Common Criteria TOE for Cisco IOS IPsec defines the following two groups of features:

- [Security Enforcing](#)
- [Security Supporting](#)



### Note

Upon delivery, a Cisco IOS router is not configured to support any of these security enforcing or supporting functions. To ensure that your router is operating in accordance with Common Criteria evaluated Cisco IOS IPsec, these functions must be explicitly configured as described in this document and in the appropriate product documentation.

## Security Enforcing

Security enforcing consists of the following functions:

- IPSec IKE using preshared keys, RSA keys, or digital certificates



**Note** Cisco 1700 series and Cisco 7200 series with an SM-VAM or SA-VAM do not support IKE with RSA keys.

- IPSec ESP using tunnel mode with DES or 3DES
- Optional hardware acceleration of IPSec (as specified in [Table 1](#))
- Cryptographic key generation and management

For information on configuring these security enforcing functions, refer to the chapters in the part “IP Security and Encryption” of the *Cisco IOS Security Configuration Guide*. (If you are using the *Cisco IOS Security Configuration Guide*, Release 12.1, use all chapters within the part “IP Security and Encryption” except the chapter “Configuring Cisco Encryption Technology.”)

To ensure that your Cisco IOS router configuration is consistent with Common Criteria evaluated Cisco IOS IPSec, you must consider the IPSec options listed in [Table 5](#).

**Table 5**      ***Evaluated Security Enforcing (IPSec) Options for Cisco IOS Routers***

| Configuration Command      | Evaluated Options | Options Not Evaluated |
|----------------------------|-------------------|-----------------------|
| crypto map (global IPSec)  | ipsec-isakmp      | ipsec-manual          |
| crypto ipsec transform-set | esp-des           | ah-md5-hmac           |
|                            | esp-3des          | ah-sha-md5            |
|                            | esp-md5-hmac      | esp-null              |
|                            | esp-sha-hmac      | comp-lzs              |
| mode (IPSec)               | tunnel            | transport             |

## Security Supporting

Security supporting consists of the following functions:

- Inbound access lists
- Message logging
- User authentication for access to the CLI using locally configured passwords.



**Note** Although Cisco IOS supports AAA user authentication, it is not supported within Common Criteria evaluated Cisco IOS IPSec.

- Time management

[Table 6](#) lists the documents that you should use to configure security supporting functions.

**Table 6      Documentation for Evaluated Security Supporting Functions**

| Feature              | Cisco IOS Documentation                                                                                                                                                                                                                                                                                      |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Inbound access lists | The chapter “Access Control Lists: Overview and Guidelines” in the part “Traffic Filtering and Firewalls” of the <i>Cisco IOS Security Configuration Guide</i><br><br>The chapter “Configuring IP Services” in the section “IP Addressing and Services” of the <i>Cisco IOS IP Routing Configuring Guide</i> |
| Message logging      | The chapter “Troubleshooting and Fault Management” in the section “System Management” of the <i>Cisco IOS Configuration Fundamentals Configuration Guide</i>                                                                                                                                                 |
| User authentication  | The chapter “Configuring Passwords and Privileges” in the part “Other Security Features” of the <i>Cisco IOS Security Configuration Guide</i>                                                                                                                                                                |
| Time management      | The chapter “Performing Basic System Management” in the part “System Management” of the <i>Cisco IOS Configuration Fundamentals Configuration Guide</i>                                                                                                                                                      |

**Saving Configurations**

When making changes to the configuration of the router, use the **write memory** command frequently. If the router reboots and resumes operation when uncommitted changes have been made, these changes will be lost and the router will revert to the last configuration saved.

**Enabling Time Stamps**

By default, all audit records are not stamped with the time and date, which are generated from the system clock when an event occurs.

The Common Criteria evaluated Cisco IOS IPSec requires that the time-stamp feature be enabled on your Cisco IOS router. To enable the time stamp of audit events, use the **service timestamps log datetime** command.

To ensure that the **timestamps** option is meaningful, the system clock in your router must be set correctly. (See the following section, “[Setting the System Clock](#),” for more information.)

**Setting the System Clock**

To provide accurate time stamps for logging and to ensure that your router can process validity dates for digital certificates, the system clock must be set. Some models of Cisco IOS routers have real-time clocks that maintain real time when the router is powered down; these real-time clocks are used to initialize the system clock at startup. Other models of Cisco IOS routers do not have a real-time clock and must obtain the correct date and time from a reliable time source using the NTP. One example of a reliable time source is a Cisco IOS router with a real-time clock operating as an NTP Server. [Table 7](#) lists router clock functions for use with Cisco IOS IPSec.

**Table 7** Cisco IOS Router Clock Functions

| Hardware Family                                             | Real-time Clock | System Clock                | Documentation                                                                                                                                           |
|-------------------------------------------------------------|-----------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cisco 1700 series<br>Cisco 2600 series<br>Cisco 3600 series | No              | NTP client                  | The chapter “Performing Basic System Management” in the part “System Management” of the <i>Cisco IOS Configuration Fundamentals Configuration Guide</i> |
| Cisco 7100 series<br>Cisco 7200 series                      | Yes             | Internal; can be NTP server | The chapter “Performing Basic System Management” in the part “System Management” of the <i>Cisco IOS Configuration Fundamentals Configuration Guide</i> |

## Hardware Versions of Hardware IPsec VPN Modules

Table 8 lists the hardware versions of IPsec VPN modules.

**Table 8** IPsec VPN Modules Hardware Versions

| Product Name | Cisco Part Number and Revisions                                                                                |
|--------------|----------------------------------------------------------------------------------------------------------------|
| SM-VAM       | 73-5953-04 A0                                                                                                  |
| SM-VAM       | 73-5953-05 A0                                                                                                  |
| SA-ISA       | 73-4201-06 A0                                                                                                  |
| SM-ISM       | 73-4201-06 B0<br>73-4201-07 A0                                                                                 |
| AIM-VPN/HP   | 800-05255-01 A0<br>800-05255-01 B0<br>800-05255-02 A0<br>800-05255-02 B0<br>800-05255-03 A0<br>800-05255-03 B0 |
| NM-VPN/MP    | 800-05213-01 A0<br>800-05213-01 B0<br>800-05213-02 A0<br>800-05213-02 B0<br>800-05213-03 A0<br>800-05213-03 B0 |

**Table 8** *IPSec VPN Modules Hardware Versions (continued)*

| Product Name | Cisco Part Number and Revisions |
|--------------|---------------------------------|
| AIM-VPN/BP   | 800-05191-01 A0                 |
|              | 800-05191-01 B0                 |
|              | 800-05191-02 A0                 |
|              | 800-05191-02 B0                 |
|              | 800-05191-03 A0                 |
|              | 800-05191-03 B0                 |
|              | 800-05191-03 C0                 |
| MOD1700-VPN  | 73-4586-01 A0                   |
|              | 73-4586-01 B0                   |
|              | 73-4586-01 C0                   |
|              | 73-4586-02 A0                   |

## MD5 Hash Values for Cisco IOS Software Images

Table 9 lists the MD5 hash values for Cisco IOS software images.

**Table 9** *Cisco IOS Software Images and MD5 Hash Values*

| Cisco IOS Image Name                   | Cisco IOS Feature Set         | MD5 Hash of Cisco IOS Image      |
|----------------------------------------|-------------------------------|----------------------------------|
| <b>Cisco 7200 with Release 12.2(6)</b> |                               |                                  |
| c7200-a3jk8s-mz.122-6.bin              | ENTERPRISE/SNASW IPSEC 56     | 2bba35bb3fb3ad57a3ae428dd89b68ab |
| c7200-dk8o3s-mz.122-6.bin              | DESKTOP/IBM/FW/IDS IPSEC 56   | 3f6a6c346157db5bbe9802ba77d0e806 |
| c7200-dk8s-mz.122-6.bin                | DESKTOP/IBM IPSEC 56          | 1f48c42614dc4e7389c3a36d491aebbc |
| c7200-ik8o3s-mz.122-6.bin              | IP/FW/IDS IPSEC 56            | 33ed2cffb43269b129fddb5822b3dcb2 |
| c7200-ik8s-mz.122-6.bin                | IP IPSEC 56                   | 768c6fd72c1db12530e5f296a2c76f87 |
| c7200-jk8o3s-mz.122-6.bin              | ENTERPRISE/FW/IDS IPSEC 56    | e4b5edcef0a1a37a64e7f71ad3ba11bc |
| c7200-jk8s-mz.122-6.bin                | ENTERPRISE IPSEC 56           | 0c2459edd5c8cad4ec4c49506c7a1ef4 |
| c7200-a3jk9s-mz.122-6.bin              | ENTERPRISE/SNASW IPSEC 3DES   | 23d373ec8d412318d2cc7fb151708b06 |
| c7200-dk9o3s-mz.122-6.bin              | DESKTOP/IBM/FW/IDS IPSEC 3DES | bf41ec3b330a129ad1f7c5c786171f66 |
| c7200-ik9o3s-mz.122-6.bin              | IP/FW/IDS IPSEC 3DES          | cd30fbe49b47092044b23605012a1b63 |
| c7200-ik9s-mz.122-6.bin                | IP PLUS IPSEC 3DES            | 2da99cd5f38c1690ee9471a98abfd439 |
| c7200-jk9o3s-mz.122-6.bin              | ENTERPRISE/FW/IDS IPSEC 3DES  | 55113e61674e9de6127902fca801042f |
| c7200-jk9s-mz.122-6.bin                | ENTERPRISE IPSEC 3DES         | 3ffabb0a54e17d9477b2555540fe4c70 |
| <b>Cisco 7100 with Release 12.2(6)</b> |                               |                                  |
| c7100-ik8o3s-mz.122-6.bin              | IP/FW/IDS IPSEC 56            | ca9bee44204316ead04a3c8a4336267  |

**Table 9 Cisco IOS Software Images and MD5 Hash Values (continued)**

|                                        |                                   |                                  |
|----------------------------------------|-----------------------------------|----------------------------------|
| c7100-ik8s-mz.122-6.bin                | IP IPSEC 56                       | a3ced0fe829ad7c40a6777afaa005b0e |
| c7100-jk8o3s-mz.122-6.bin              | ENTERPRISE/FW/IDS IPSEC 56        | eef9dc5fea1161c20463d43ab2a9a690 |
| c7100-jk8s-mz.122-6.bin                | ENTERPRISE IPSEC 56               | a3602b17af5326c481f025304c9f484a |
| c7100-ik9o3s-mz.122-6.bin              | IP/FW/IDS IPSEC 3DES              | f3a8931ee123b3e9c00be8f0eb089135 |
| c7100-ik9s-mz.122-6.bin                | IP PLUS IPSEC 3DES                | 89af8e880183966df771342380e9e187 |
| c7100-jk9o3s-mz.122-6.bin              | ENTERPRISE/FW/IDS PLUS IPSEC 3DES | 13892de3e4b2fa41281cb1d43bf6c466 |
| c7100-jk9s-mz.122-6.bin                | ENTERPRISE IPSEC 3DES             | 18cc0684514e139632f5acaede74ef85 |
| <b>Cisco 3660 with Release 12.2(6)</b> |                                   |                                  |
| c3660-a3jk8s-mz.122-6.bin              | ENTERPRISE/SNASW PLUS IPSEC 56    | 577561c774dcda1d071b6d0532f81525 |
| c3660-ik8o3s-mz.122-6.bin              | IP/FW/IDS PLUS IPSEC 56           | 4603a8418270ebc10f566c96cc14be0f |
| c3660-ik8s-mz.122-6.bin                | IP PLUS IPSEC 56                  | f3dd2581c7e0dd53aec57dfd011c7333 |
| c3660-jk8o3s-mz.122-6.bin              | ENTERPRISE/FW/IDS PLUS IPSEC 56   | 48385b255a67d79b3353fb1586b1a035 |
| c3660-jk8s-mz.122-6.bin                | ENTERPRISE PLUS IPSEC 56          | 36e2be7a4a4d1c93287e92adf89d1ff5 |
| c3660-a3jk9s-mz.122-6.bin              | ENTERPRISE/SNASW PLUS IPSEC 3DES  | e3496987d62172ac1c857c36b963274e |
| c3660-ik9o3s-mz.122-6.bin              | IP/FW/IDS PLUS IPSEC 3DES         | 55f4b6acfd66b8af01b429b86e8cc9c  |
| c3660-ik9s-mz.122-6.bin                | IP PLUS IPSEC 3DES                | b280c20a3497497114901f9e2adddb1a |
| c3660-jk9o3s-mz.122-6.bin              | ENTERPRISE/FW/IDS PLUS IPSEC 3DES | f24bb356009043608c6b296d8833eae  |
| c3660-jk9s-mz.122-6.bin                | ENTERPRISE PLUS IPSEC 3DES        | 0757b1cb6542ef313e5185a933199769 |
| c3660-telcoentk9-mz.122-6.bin          | TELCO PLUS FEATURE SET IPSEC 3DES | c9d2e81d481694d1fa8f880ea6ae5483 |
| <b>Cisco 3640 with Release 12.2(6)</b> |                                   |                                  |
| c3640-a3jk8s-mz.122-6.bin              | ENTERPRISE/SNASW PLUS IPSEC 56    | 64628ec89ef2fedc42e7f0219fc9a452 |
| c3640-ik8o3s-mz.122-6.bin              | IP/FW/IDS PLUS IPSEC 56           | 3b10309c8579b01eac782a81a578ee8e |
| c3640-ik8s-mz.122-6.bin                | IP PLUS IPSEC 56                  | 2a46dc9d669b58066f0765be2b22404d |
| c3640-jk8o3s-mz.122-6.bin              | ENTERPRISE/FW/IDS PLUS IPSEC 56   | 8c25d0115b66bef3212a8f3a7c29da06 |
| c3640-jk8s-mz.122-6.bin                | ENTERPRISE PLUS IPSEC 56          | 6bef9253e93eb7d83398513c34f9352d |
| c3640-a3jk9s-mz.122-6.bin              | ENTERPRISE/SNASW PLUS IPSEC 3DES  | c79a35c30a3765771b66cbdd4296539c |
| c3640-ik9o3s-mz.122-6.bin              | IP/FW/IDS PLUS IPSEC 3DES         | ddb8fee165877102d0f8f99855ee5ef4 |
| c3640-ik9s-mz.122-6.bin                | IP PLUS IPSEC 3DES                | ce948b710f9ab9422574a9ef5ea482cd |
| c3640-jk9o3s-mz.122-6.bin              | ENTERPRISE/FW/IDS PLUS IPSEC 3DES | dc4c0a9c29726fb54cbdd60fcfd7770  |
| c3640-jk9s-mz.122-6.bin                | ENTERPRISE PLUS IPSEC 3DES        | 3a4541c32e1f822407da77e07cdaeb1b |



**Table 9 Cisco IOS Software Images and MD5 Hash Values (continued)**

| <b>Cisco 3620 with Release 12.2(6)</b>                               |                                          |                                   |
|----------------------------------------------------------------------|------------------------------------------|-----------------------------------|
| c3620-a3jk8s-mz.122-6.bin                                            | ENTERPRISE/SNASW PLUS IPSEC 56           | b8bc2a854ce9c593576d0c22df911ffb  |
| c3620-ik8o3s-mz.122-6.bin                                            | IP/FW/IDS PLUS IPSEC 56                  | 5d581350115e34ecd5a95849776edcc3  |
| c3620-ik8s-mz.122-6.bin                                              | IP PLUS IPSEC 56                         | 3a41053365bb5997bfff0f2b723659e12 |
| c3620-jk8o3s-mz.122-6.bin                                            | ENTERPRISE/FW/IDS PLUS IPSEC 56          | 5126fac09c7c6285ca690d48c62a541f  |
| c3620-jk8s-mz.122-6.bin                                              | ENTERPRISE PLUS IPSEC 56                 | 77bb989d83777634d0d3bcd7390acf56  |
| c3620-a3jk9s-mz.122-6.bin                                            | ENTERPRISE/SNASW PLUS IPSEC 3DES         | c3126eb3d24bcf2f39f4740c5cdf5501  |
| c3620-ik9o3s-mz.122-6.bin                                            | IP/FW/IDS PLUS IPSEC 3DES                | 02f7a7ee7f350a93f25046abd62e3ac5  |
| c3620-ik9s-mz.122-6.bin                                              | IP PLUS IPSEC 3DES                       | d7b34c3fb5c9789dd573e42c92d19470  |
| c3620-jk9o3s-mz.122-6.bin                                            | ENTERPRISE/FW/IDS PLUS IPSEC 3DES        | 3c7a7b74d9de5eda9ce4e586947626d8  |
| c3620-jk9s-mz.122-6.bin                                              | ENTERPRISE PLUS IPSEC 3DES               | 2ce8f930608141e0837e8dd13befc846  |
| <b>Cisco 2610, 2611, 2612, 2613, 2620, 2621 with Release 12.2(6)</b> |                                          |                                   |
| c2600-a3jk8s-mz.122-6.bin                                            | ENTERPRISE/SNASW PLUS IPSEC 56           | 86538a8ce471bbfaf80810c2b6a4d0cf  |
| c2600-ik8o3s-mz.122-6.bin                                            | IP/FW/IDS PLUS IPSEC 56                  | 4738d6597f8933548e4dcd1e9b8e610f  |
| c2600-ik8s-mz.122-6.bin                                              | IP PLUS IPSEC 56                         | 6641d9b29a71e9c2d3d44e113a32b6b0  |
| c2600-jk8o3s-mz.122-6.bin                                            | ENTERPRISE/FW/IDS PLUS IPSEC 56          | 9a1f1cafbfb634ad7dd24d7f67a320ec  |
| c2600-jk8s-mz.122-6.bin                                              | ENTERPRISE PLUS IPSEC 56                 | 34cc47b34ca5c64e24199e4261826cd8  |
| c2600-a3jk9s-mz.122-6.bin                                            | ENTERPRISE/SNASW PLUS IPSEC 3DES         | c3fdc6e04b4a004cabe745221a3110d1  |
| c2600-ik9o3s-mz.122-6.bin                                            | IP/FW/IDS PLUS IPSEC 3DES                | 4c3d7dc8812ae4fff08a2dbd3d536589  |
| c2600-ik9s-mz.122-6.bin                                              | IP PLUS IPSEC 3DES                       | d15df41a51d57bba2ddfff3e38f38c95  |
| c2600-jk9o3s-mz.122-6.bin                                            | ENTERPRISE/FW/IDS PLUS IPSEC 3DES        | a90eb23c2370a810bfd1702788c9ccce  |
| c2600-jk9s-mz.122-6.bin                                              | ENTERPRISE PLUS IPSEC 3DES               | 08c63c3c9ba4942e5ce097bd38805ff3  |
| <b>Cisco 1750 with Release 12.2(6)</b>                               |                                          |                                   |
| c1700-bk8no3r2sv3y-mz.122-6.bin                                      | IP/IPX/AT/IBM/VOICE/FW/IDS PLUS IPSEC 56 | fe365f6b9233dbc861ab6f7dfe95b78   |
| c1700-k8o3sv3y-mz.122-6.bin                                          | IP/VOICE/FW/IDS PLUS IPSEC 56            | 366c0728a7d33b06f688c72b4a9df8c1  |
| c1700-k8sv3y-mz.122-6.bin                                            | IP/VOICE PLUS IPSEC 56                   | cf5fb5c321ca166737bf9b879510f5d0  |
| c1700-bk9no3r2sv3y-mz.122-6.bin                                      | IP/IPX/AT/IBM/VO/FW/IDS PLUS IPSEC 3DES  | 39131f81690552319552d5dc926a7a30  |
| c1700-k9o3sv3y-mz.122-6.bin                                          | IP/VOICE/FW/IDS PLUS IPSEC 3DES          | 7a39d0528439b787aaa6f200af8fabb9  |
| c1700-k9sv3y-mz.122-6.bin                                            | IP/VOICE PLUS IPSEC 3DES                 | c398b885becaa574bbc21775a4b9cd1c  |

**Table 9 Cisco IOS Software Images and MD5 Hash Values (continued)**

|                                          |                                      |                                   |
|------------------------------------------|--------------------------------------|-----------------------------------|
| <b>Cisco 1720 with Release 12.2(6)</b>   |                                      |                                   |
| c1700-bk8no3r2sy-mz.122-6.bin            | IP/IPX/AT/IBM/FW/IDS PLUS IPSEC 56   | 3a68e7c3edf00e4947dec02de2215742  |
| c1700-k8o3sy-mz.122-6.bin                | IP/FW/IDS PLUS IPSEC 56              | 075a7dc676c0f7daae98400d78fca76   |
| c1700-k8sy-mz.122-6.bin                  | IP PLUS IPSEC 56                     | 2a7bba62a26c790ad0c1a667e28b5010  |
| c1700-bk9no3r2sy-mz.122-6.bin            | IP/IPX/AT/IBM/FW/IDS PLUS IPSEC 3DES | dbb2e4dac4dbba36ce4ec4f7da4c12d0  |
| c1700-k9o3sy-mz.122-6.bin                | IP/FW/IDS PLUS IPSEC 3DES            | ce2eab199ca8359c214ecfb48e34e988  |
| c1700-k9sy-mz.122-6.bin                  | IP PLUS IPSEC 3DES                   | ea02f8cc86da69c20a73753df99aa3d   |
| <b>Cisco 7200 with Release 12.1(10)E</b> |                                      |                                   |
| c7200-do3s56i-mz.121-10.E.bin            | DESKTOP/IBM/FW/IDS IPSEC 56          | b26914e12a462d2bddc24951a5878cde  |
| c7200-ds56i-mz.121-10.E.bin              | DESKTOP/IBM IPSEC 56                 | b16e652f01b5b99337cedfa63392a840  |
| c7200-io3s56i-mz.121-10.E.bin            | IP/FW/IDS IPSEC 56                   | 708dece58caf4f1aaf63a4ff0dd53a97  |
| c7200-is56i-mz.121-10.E.bin              | IP IPSEC 56                          | f28797dd82ca3c51ba084a8df5b93fc9  |
| c7200-jo3s56i-mz.121-10.E.bin            | ENTERPRISE/FW/IDS IPSEC 56           | c3dad78a560ad6c4f402e641939be015  |
| c7200-js56i-mz.121-10.E.bin              | ENTERPRISE IPSEC 56                  | b2068f05d074f60650be967781e74701  |
| c7200-dk2o3s-mz.121-10.E.bin             | DESKTOP/IBM/FW/IDS IPSEC 3DES        | 6044f68393adeb3900f0249beccc4c43  |
| c7200-ik2o3s-mz.121-10.E.bin             | IP/FW/IDS IPSEC 3DES                 | 54e767b0ed4e0f953c330ca36fbe1396  |
| c7200-ik2s-mz.121-10.E.bin               | IP PLUS IPSEC 3DES                   | 022e757fcccc0efec403e7ab0b48759b  |
| c7200-jk2o3s-mz.121-10.E.bin             | ENTERPRISE/FW/IDS IPSEC 3DES         | cc042f8972b75c841cd4e8740cbae9e4  |
| c7200-jk2s-mz.121-10.E.bin               | ENTERPRISE IPSEC 3DES                | 3b5b54158a719cdcd1573fa75fa88acd  |
| <b>Cisco 7100 with Release 12.1(10)E</b> |                                      |                                   |
| c7100-io3s56i-mz.121-10.E.bin            | IP/FW/IDS IPSEC 56                   | 6a3fe1d410ead1f5ef01c8a0dc7338af  |
| c7100-is56i-mz.121-10.E.bin              | IP IPSEC 56                          | 3f14e2c1a0dcab28531516f31ddbc4c8  |
| c7100-jo3s56i-mz.121-10.E.bin            | ENTERPRISE/FW/IDS IPSEC 56           | e29bcd00e4deabc8f60667c42de5b35   |
| c7100-js56i-mz.121-10.E.bin              | ENTERPRISE IPSEC 56                  | 3b9e4ba61194994c61bc83a8334ddf44  |
| c7100-ik2o3s-mz.121-10.E.bin             | IP/FW/IDS IPSEC 3DES                 | f73fbdd8cb69a7bb5822ecfb1f40ad01  |
| c7100-ik2s-mz.121-10.E.bin               | IP PLUS IPSEC 3DES                   | fbec1eddbde89408eca5b1dd680c9c39c |
| c7100-jk2o3s-mz.121-10.E.bin             | ENTERPRISE/FW/IDS PLUS IPSEC 3DES    | ff1ca727b58614369306fa600eacfc41  |
| c7100-jk2s-mz.121-10.E.bin               | ENTERPRISE IPSEC 3DES                | f052d9acbeb51ddb4f486f90d228e6ba  |

For verification of MD5 hash values, contact Cisco Technical Support.

## Related Documentation

Use this document in conjunction with the appropriate Cisco IOS software documentation, which can be found at the following location:

Documentation for Cisco IOS Release 12.1:

<http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/index.htm>

Documentation for Cisco IOS Release 12.2:

<http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/index.htm>

## Obtaining Documentation

The following sections provide sources for obtaining documentation from Cisco Systems.

### World Wide Web

The most current Cisco documentation is available on the World Wide Web at the following website:

<http://www.cisco.com>

Translated documentation is available at the following website:

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

### Documentation CD-ROM

Cisco documentation and additional literature are available in a CD-ROM package, which ships with your product. The Documentation CD-ROM is updated monthly and may be more current than printed documentation. The CD-ROM package is available as a single unit or through an annual subscription.

## Ordering Documentation

Cisco documentation can be ordered in the following ways:

- Registered Cisco Direct Customers can order Cisco product documentation from the Networking Products MarketPlace:  
[http://www.cisco.com/cgi-bin/order/order\\_root.pl](http://www.cisco.com/cgi-bin/order/order_root.pl)
- Registered Cisco.com users can order the Documentation CD-ROM through the online Subscription Store:  
<http://www.cisco.com/go/subscription>
- Nonregistered Cisco.com users can order documentation through a local account representative by calling Cisco corporate headquarters (California, USA) at 408 526-7208 or, in North America, by calling 800 553-NETS(6387).

## Documentation Feedback

If you are reading Cisco product documentation on the World Wide Web, you can submit technical comments electronically. Click **Feedback** in the toolbar and select **Documentation**. After you complete the form, click **Submit** to send it to Cisco.

You can e-mail your comments to [bug-doc@cisco.com](mailto:bug-doc@cisco.com).

To submit your comments by mail, use the response card behind the front cover of your document, or write to the following address:

Cisco Systems, Inc.  
Document Resource Connection  
170 West Tasman Drive  
San Jose, CA 95134-9883

We appreciate your comments.

## Obtaining Technical Assistance

Cisco provides Cisco.com as a starting point for all technical assistance. Customers and partners can obtain documentation, troubleshooting tips, and sample configurations from online tools. For Cisco.com registered users, additional troubleshooting tools are available from the TAC website.

### Cisco.com

Cisco.com is the foundation of a suite of interactive, networked services that provides immediate, open access to Cisco information and resources at anytime, from anywhere in the world. This highly integrated Internet application is a powerful, easy-to-use tool for doing business with Cisco.

Cisco.com provides a broad range of features and services to help customers and partners streamline business processes and improve productivity. Through Cisco.com, you can find information about Cisco and our networking solutions, services, and programs. In addition, you can resolve technical issues with online technical support, download and test software packages, and order Cisco learning materials and merchandise. Valuable online skill assessment, training, and certification programs are also available.

Customers and partners can self-register on Cisco.com to obtain additional personalized information and services. Registered users can order products, check on the status of an order, access technical support, and view benefits specific to their relationships with Cisco.

To access Cisco.com, go to the following website:

<http://www.cisco.com>

## Technical Assistance Center

The Cisco TAC website is available to all customers who need technical assistance with a Cisco product or technology that is under warranty or covered by a maintenance contract.

## Contacting TAC by Using the Cisco TAC Website

If you have a priority level 3 (P3) or priority level 4 (P4) problem, contact TAC by going to the TAC website:

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

P3 and P4 level problems are defined as follows:

- P3—Your network performance is degraded. Network functionality is noticeably impaired, but most business operations continue.
- P4—You need information or assistance on Cisco product capabilities, product installation, or basic product configuration.

In each of the above cases, use the Cisco TAC website to quickly find answers to your questions.

To register for Cisco.com, go to the following website:

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

If you cannot resolve your technical issue by using the TAC online resources, Cisco.com registered users can open a case online by using the TAC Case Open tool at the following website:

<http://www.cisco.com/tac/caseopen>

## Contacting TAC by Telephone

If you have a priority level 1 (P1) or priority level 2 (P2) problem, contact TAC by telephone and immediately open a case. To obtain a directory of toll-free numbers for your country, go to the following website:

<http://www.cisco.com/warp/public/687/Directory/DirTAC.shtml>

P1 and P2 level problems are defined as follows:

- P1—Your production network is down, causing a critical impact to business operations if service is not restored quickly. No workaround is available.
- P2—Your production network is severely degraded, affecting significant aspects of your business operations. No workaround is available.

CCVP, the Cisco logo, and Welcome to the Human Network are trademarks of Cisco Systems, Inc.; Changing the Way We Work, Live, Play, and Learn is a service mark of Cisco Systems, Inc.; and Access Registrar, Aironet, Catalyst, CCDA, CCDP, CCIE, CCIP, CCNA, CCNP, CCSP, Cisco, the Cisco Certified Internetwork Expert logo, Cisco IOS, Cisco Press, Cisco Systems, Cisco Systems Capital, the Cisco Systems logo, Cisco Unity, Enterprise/Solver, EtherChannel, EtherFast, EtherSwitch, Fast Step, Follow Me Browsing, FormShare, GigaDrive, HomeLink, Internet Quotient, IOS, iPhone, IP/TV, iQ Expertise, the iQ logo, iQ Net Readiness Scorecard, iQuick Study, LightStream, Linksys, MeetingPlace, MGX, Networkers, Networking Academy, Network Registrar, PIX, ProConnect, ScriptShare, SMARTnet, StackWise, The Fastest Way to Increase Your Internet Quotient, and TransPath are registered trademarks of Cisco Systems, Inc. and/or its affiliates in the United States and certain other countries.

All other trademarks mentioned in this document or Website are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (0711R)