Cisco IOS IP Switching Configuration Guide

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About Cisco IOS and Cisco IOS XE Software Documentation

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This document describes the objectives, audience, conventions, and organization used in Cisco IOS and Cisco IOS XE software documentation, collectively referred to in this document as Cisco IOS documentation. Also included are resources for obtaining technical assistance, additional documentation, and other information from Cisco. This document is organized into the following sections:

Documentation Objectives

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

Audience

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

Documentation Conventions

In Cisco IOS documentation, the term *router* may be used to refer to various Cisco products; for example, routers, access servers, and switches. These and other networking devices that support Cisco IOS software are shown interchangeably in examples and are used only for illustrative purposes. An example that shows one product does not necessarily mean that other products are not supported.

This section includes the following topics:

Typographic Conventions

Cisco IOS documentation uses the following typographic conventions:

Convention	Description
^ or Ctrl	Both the ^ symbol and Ctrl represent the Control (Ctrl) key on a keyboard. For example, the key combination **^D** or **Ctrl-D** means that you hold down the Control key while you press the D key. (Keys are indicated in capital letters but are not case sensitive.)
string	A string is a nonquoted set of characters shown in italics. For example, when setting a Simple Network Management Protocol (SNMP) community string to *public*, do not use quotation marks around the string; otherwise, the string will include the quotation marks.

Command Syntax Conventions

Cisco IOS documentation uses the following command syntax conventions:

Convention	Description
bold	Bold text indicates commands and keywords that you enter as shown.
italic	Italic text indicates arguments for which you supply values.
[x]	Square brackets enclose an optional keyword or argument.
|	A vertical line, called a pipe, indicates a choice within a set of keywords or arguments.
[x | y]	Square brackets enclosing keywords or arguments separated by a pipe indicate an optional choice.
{x | y}	Braces enclosing keywords or arguments separated by a pipe indicate a required choice.
[x {y | z}]	Braces and a pipe within square brackets indicate a required choice within an optional element.

Software Conventions

Cisco IOS uses the following program code conventions:

Convention	Description
`Courier font`	Courier font is used for information that is displayed on a PC or terminal screen.
`Bold Courier font`	Bold Courier font indicates text that the user must enter.
< >	Angle brackets enclose text that is not displayed, such as a password. Angle brackets also are used in contexts in which the italic font style is not supported; for example, ASCII text.
!	An exclamation point at the beginning of a line indicates that the text that follows is a comment, not a line of code. An exclamation point is also displayed by Cisco IOS software for certain processes.
[ ]	Square brackets enclose default responses to system prompts.

Reader Alert Conventions

The Cisco IOS documentation set uses the following conventions for reader alerts:

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 material not covered in the manual.

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

Documentation Organization

This section describes the Cisco IOS documentation set, how it is organized, and how to access it on Cisco.com. Included are lists of configuration guides, command references, and supplementary references and resources that make up the documentation set. The following topics are included:

Cisco IOS Documentation Set

Cisco IOS documentation consists of the following:

- Release notes and caveats provide information about platform, technology, and feature support for a release and describe severity 1 (catastrophic), severity 2 (severe), and severity 3 (moderate) defects in released Cisco IOS code. Review release notes before other documents to learn whether or not updates have been made to a feature.
- Sets of configuration guides and command references organized by technology and published for each standard Cisco IOS release.
  - Configuration guides—Compilations of documents that provide informational and task-oriented descriptions of Cisco IOS features.
  - Command references—Compilations of command pages that provide detailed information about the commands used in the Cisco IOS features and processes that make up the related configuration guides. For each technology, there is a single command reference that covers all Cisco IOS releases and that is updated at each standard release.
- Lists of all the commands in a specific release and all commands that are new, modified, removed, or replaced in the release.
- Command reference book for **debug** commands. Command pages are listed in alphabetical order.
- Reference book for system messages for all Cisco IOS releases.

Cisco IOS Documentation on Cisco.com

The following sections describe the documentation organization and how to access various document types.

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

New Features List

The New Features List for each release provides a list of all features in the release with hyperlinks to the feature guides in which they are documented.

Feature Guides

Cisco IOS features are documented in feature guides. Feature guides describe one feature or a group of related features that are supported on many different software releases and platforms. Your Cisco IOS software release or platform may not support all the features documented in a feature guide. See the Feature Information table at the end of the feature guide for information about which features in that guide are supported in your software release.

Configuration Guides

Configuration guides are provided by technology and release and comprise a set of individual feature guides relevant to the release and technology.

Command References

Command reference books describe Cisco IOS commands that are supported in many different software releases and on many different platforms. The books are provided by technology. For information about all Cisco IOS commands, use the Command Lookup Tool at http://tools.cisco.com/Support/CLILookup or the *Cisco IOS Master Command List, All Releases*, at http://www.cisco.com/en/US/docs/ios/mcl/all_release/all_mcl.html.

Cisco IOS Supplementary Documents and Resources

Supplementary documents and resources are listed in Table 2 on page xi.

Configuration Guides, Command References, and Supplementary Resources

Table 1 lists, in alphabetical order, Cisco IOS and Cisco IOS XE software configuration guides and command references, including brief descriptions of the contents of the documents. The Cisco IOS command references are comprehensive, meaning that they include commands for both Cisco IOS software and Cisco IOS XE software, for all releases. The configuration guides and command references support many different software releases and platforms. Your Cisco IOS software release or platform may not support all these technologies.

For additional information about configuring and operating specific networking devices, go to the Product Support area of Cisco.com at http://www.cisco.com/web/psa/products/index.html.

Table 2 lists documents and resources that supplement the Cisco IOS software configuration guides and command references. These supplementary resources include release notes and caveats; master command lists; new, modified, removed, and replaced command lists; system messages; and the debug command reference.

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS AppleTalk Configuration Guide *Cisco IOS XE AppleTalk Configuration Guide* *Cisco IOS AppleTalk Command Reference*	AppleTalk protocol.
Cisco IOS Asynchronous Transfer Mode Configuration Guide *Cisco IOS Asynchronous Transfer Mode Command Reference*	LAN ATM, multiprotocol over ATM (MPoA), and WAN ATM.

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References (continued)

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS Bridging and IBM Networking Configuration Guide *Cisco IOS Bridging Command Reference* *Cisco IOS IBM Networking Command Reference*	• Transparent and source-route transparent (SRT) bridging, source-route bridging (SRB), Token Ring Inter-Switch Link (TRISL), and token ring route switch module (TRRSM). • Data-link switching plus (DLSw+), serial tunnel (STUN), block serial tunnel (BSTUN); logical link control, type 2 (LLC2), synchronous data link control (SDLC); IBM Network Media Translation, including Synchronous Data Logical Link Control (SDLLC) and qualified LLC (QLLC); downstream physical unit (DSPU), Systems Network Architecture (SNA) service point, SNA frame relay access, advanced peer-to-peer networking (APPN), native client interface architecture (NCIA) client/server topologies, and IBM Channel Attach.
Cisco IOS Broadband and DSL Configuration Guide *Cisco IOS XE Broadband and DSL Configuration Guide* *Cisco IOS Broadband and DSL Command Reference*	Point-to-Point Protocol (PPP) over ATM (PPPoA) and PPP over Ethernet (PPPoE).
Cisco IOS Carrier Ethernet Configuration Guide *Cisco IOS Carrier Ethernet Command Reference*	Connectivity fault management (CFM), Ethernet Local Management Interface (ELMI), IEEE 802.3ad link bundling, Link Layer Discovery Protocol (LLDP), media endpoint discovery (MED), and operations, administration, and maintenance (OAM).
Cisco IOS Configuration Fundamentals Configuration Guide *Cisco IOS XE Configuration Fundamentals Configuration Guide* *Cisco IOS Configuration Fundamentals Command Reference*	Autoinstall, Setup, Cisco IOS command-line interface (CLI), Cisco IOS file system (IFS), Cisco IOS web browser user interface (UI), basic file transfer services, and file management.
Cisco IOS DECnet Configuration Guide *Cisco IOS XE DECnet Configuration Guide* *Cisco IOS DECnet Command Reference*	DECnet protocol.
Cisco IOS Dial Technologies Configuration Guide *Cisco IOS XE Dial Technologies Configuration Guide* *Cisco IOS Dial Technologies Command Reference*	Asynchronous communications, dial backup, dialer technology, dial-in terminal services and AppleTalk remote access (ARA), large scale dialout, dial-on-demand routing, dialout, modem and resource pooling, ISDN, multilink PPP (MLP), PPP, virtual private dialup network (VPDN).
Cisco IOS Flexible NetFlow Configuration Guide *Cisco IOS Flexible NetFlow Command Reference*	Flexible NetFlow.

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References (continued)

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS H.323 Configuration Guide	Gatekeeper enhancements for managed voice services, Gatekeeper Transaction Message Protocol, gateway codec order preservation and shutdown control, H.323 dual tone multifrequency relay, H.323 version 2 enhancements, Network Address Translation (NAT) support of H.323 v2 Registration, Admission, and Status (RAS) protocol, tokenless call authorization, and VoIP gateway trunk and carrier-based routing.
Cisco IOS High Availability Configuration Guide *Cisco IOS XE High Availability Configuration Guide* *Cisco IOS High Availability Command Reference*	A variety of High Availability (HA) features and technologies that are available for different network segments (from enterprise access to service provider core) to facilitate creation of end-to-end highly available networks. Cisco IOS HA features and technologies can be categorized in three key areas: system-level resiliency, network-level resiliency, and embedded management for resiliency.
Cisco IOS Integrated Session Border Controller Command Reference	A VoIP-enabled device that is deployed at the edge of networks. An SBC is a toolkit of functions, such as signaling interworking, network hiding, security, and quality of service (QoS).
Cisco IOS Intelligent Service Gateway Configuration Guide *Cisco IOS Intelligent Service Gateway Command Reference*	Subscriber identification, service and policy determination, session creation, session policy enforcement, session life-cycle management, accounting for access and service usage, session state monitoring.
Cisco IOS Interface and Hardware Component Configuration Guide *Cisco IOS XE Interface and Hardware Component Configuration Guide* *Cisco IOS Interface and Hardware Component Command Reference*	LAN interfaces, logical interfaces, serial interfaces, virtual interfaces, and interface configuration.
Cisco IOS IP Addressing Services Configuration Guide *Cisco IOS XE Addressing Services Configuration Guide* *Cisco IOS IP Addressing Services Command Reference*	Address Resolution Protocol (ARP), Network Address Translation (NAT), Domain Name System (DNS), Dynamic Host Configuration Protocol (DHCP), and Next Hop Address Resolution Protocol (NHRP).
Cisco IOS IP Application Services Configuration Guide *Cisco IOS XE IP Application Services Configuration Guide* *Cisco IOS IP Application Services Command Reference*	Enhanced Object Tracking (EOT), Gateway Load Balancing Protocol (GLBP), Hot Standby Router Protocol (HSRP), IP Services, Server Load Balancing (SLB), Stream Control Transmission Protocol (SCTP), TCP, Web Cache Communication Protocol (WCCP), User Datagram Protocol (UDP), and Virtual Router Redundancy Protocol (VRRP).
Cisco IOS IP Mobility Configuration Guide *Cisco IOS IP Mobility Command Reference*	Mobile ad hoc networks (MANet) and Cisco mobile networks.
Cisco IOS IP Multicast Configuration Guide *Cisco IOS XE IP Multicast Configuration Guide* *Cisco IOS IP Multicast Command Reference*	Protocol Independent Multicast (PIM) sparse mode (PIM-SM), bidirectional PIM (bidir-PIM), Source Specific Multicast (SSM), Multicast Source Discovery Protocol (MSDP), Internet Group Management Protocol (IGMP), and Multicast VPN (MVPN).

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References (continued)

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS IP Routing Protocols Configuration Guide *Cisco IOS XE IP Routing Protocols Configuration Guide* *Cisco IOS IP Routing Protocols Command Reference*	Border Gateway Protocol (BGP), multiprotocol BGP, multiprotocol BGP extensions for IP multicast, bidirectional forwarding detection (BFD), Enhanced Interior Gateway Routing Protocol (EIGRP), Interior Gateway Routing Protocol (IGRP), Intermediate System-to-Intermediate System (IS-IS), on-demand routing (ODR), Open Shortest Path First (OSPF), and Routing Information Protocol (RIP).
Cisco IOS IP SLAs Configuration Guide *Cisco IOS XE IP SLAs Configuration Guide* *Cisco IOS IP SLAs Command Reference*	Cisco IOS IP Service Level Agreements (IP SLAs).
Cisco IOS IP Switching Configuration Guide *Cisco IOS XE IP Switching Configuration Guide* *Cisco IOS IP Switching Command Reference*	Cisco Express Forwarding, fast switching, and Multicast Distributed Switching (MDS).
Cisco IOS IPv6 Configuration Guide *Cisco IOS XE IPv6 Configuration Guide* *Cisco IOS IPv6 Command Reference*	For IPv6 features, protocols, and technologies, go to the IPv6 "Start Here" document at the following URL: http://www.cisco.com/en/US/docs/ios/ipv6/configuration/guide/ip6-roadmap.html
Cisco IOS ISO CLNS Configuration Guide *Cisco IOS XE ISO CLNS Configuration Guide* *Cisco IOS ISO CLNS Command Reference*	ISO connectionless network service (CLNS).
Cisco IOS LAN Switching Configuration Guide *Cisco IOS XE LAN Switching Configuration Guide* *Cisco IOS LAN Switching Command Reference*	VLANs, Inter-Switch Link (ISL) encapsulation, IEEE 802.10 encapsulation, IEEE 802.1Q encapsulation, and multilayer switching (MLS).
Cisco IOS Mobile Wireless Gateway GPRS Support Node Configuration Guide *Cisco IOS Mobile Wireless Gateway GPRS Support Node Command Reference*	Cisco IOS Gateway GPRS Support Node (GGSN) in a 2.5-generation general packet radio service (GPRS) and 3-generation universal mobile telecommunication system (UMTS) network.
Cisco IOS Mobile Wireless Home Agent Configuration Guide *Cisco IOS Mobile Wireless Home Agent Command Reference*	Cisco Mobile Wireless Home Agent, an anchor point for mobile terminals for which mobile IP or proxy mobile IP services are provided.
Cisco IOS Mobile Wireless Packet Data Serving Node Configuration Guide *Cisco IOS Mobile Wireless Packet Data Serving Node Command Reference*	Cisco Packet Data Serving Node (PDSN), a wireless gateway that is between the mobile infrastructure and standard IP networks and that enables packet data services in a code division multiple access (CDMA) environment.
Cisco IOS Mobile Wireless Radio Access Networking Configuration Guide *Cisco IOS Mobile Wireless Radio Access Networking Command Reference*	Cisco IOS radio access network products.

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References (continued)

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS Multiprotocol Label Switching Configuration Guide *Cisco IOS XE Multiprotocol Label Switching Configuration Guide* *Cisco IOS Multiprotocol Label Switching Command Reference*	MPLS Label Distribution Protocol (LDP), MPLS Layer 2 VPNs, MPLS Layer 3 VPNs, MPLS Traffic Engineering (TE), and MPLS Embedded Management (EM) and MIBs.
Cisco IOS Multi-Topology Routing Configuration Guide *Cisco IOS Multi-Topology Routing Command Reference*	Unicast and multicast topology configurations, traffic classification, routing protocol support, and network management support.
Cisco IOS NetFlow Configuration Guide *Cisco IOS XE NetFlow Configuration Guide* *Cisco IOS NetFlow Command Reference*	Network traffic data analysis, aggregation caches, export features.
Cisco IOS Network Management Configuration Guide *Cisco IOS XE Network Management Configuration Guide* *Cisco IOS Network Management Command Reference*	Basic system management; system monitoring and logging; troubleshooting, logging, and fault management; Cisco Discovery Protocol; Cisco IOS Scripting with Tool Control Language (Tcl); Cisco networking services (CNS); DistributedDirector; Embedded Event Manager (EEM); Embedded Resource Manager (ERM); Embedded Syslog Manager (ESM); HTTP; Remote Monitoring (RMON); SNMP; and VPN Device Manager Client for Cisco IOS Software (XSM Configuration).
Cisco IOS Novell IPX Configuration Guide *Cisco IOS XE Novell IPX Configuration Guide* *Cisco IOS Novell IPX Command Reference*	Novell Internetwork Packet Exchange (IPX) protocol.
Cisco IOS Optimized Edge Routing Configuration Guide *Cisco IOS Optimized Edge Routing Command Reference*	Optimized edge routing (OER) monitoring, policy configuration, routing control, logging and reporting, and VPN IPsec/generic routing encapsulation (GRE) tunnel interface optimization.
Cisco IOS Quality of Service Solutions Configuration Guide *Cisco IOS XE Quality of Service Solutions Configuration Guide* *Cisco IOS Quality of Service Solutions Command Reference*	Class-based weighted fair queuing (CBWFQ), custom queuing, distributed traffic shaping (DTS), generic traffic shaping (GTS), IP- to-ATM class of service (CoS), low latency queuing (LLQ), modular QoS CLI (MQC), Network-Based Application Recognition (NBAR), priority queuing, Security Device Manager (SDM), Multilink PPP (MLPPP) for QoS, header compression, AutoQoS, QoS features for voice, Resource Reservation Protocol (RSVP), weighted fair queuing (WFQ), and weighted random early detection (WRED).
Cisco IOS Security Configuration Guide *Cisco IOS XE Security Configuration Guide* *Cisco IOS Security Command Reference*	Access control lists (ACLs), authentication, authorization, and accounting (AAA), firewalls, IP security and encryption, neighbor router authentication, network access security, network data encryption with router authentication, public key infrastructure (PKI), RADIUS, TACACS+, terminal access security, and traffic filters.

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References (continued)

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS Service Selection Gateway Configuration Guide *Cisco IOS Service Selection Gateway Command Reference*	Subscriber authentication, service access, and accounting.
Cisco IOS Software Activation Configuration Guide *Cisco IOS Software Activation Command Reference*	An orchestrated collection of processes and components to activate Cisco IOS software feature sets by obtaining and validating Cisco software licenses.
Cisco IOS Software Modularity Installation and Configuration Guide *Cisco IOS Software Modularity Command Reference*	Installation and basic configuration of software modularity images, including installations on single and dual route processors, installation rollbacks, software modularity binding, software modularity processes and patches.
Cisco IOS Terminal Services Configuration Guide *Cisco IOS Terminal Services Command Reference* *Cisco IOS XE Terminal Services Command Reference*	DEC, local-area transport (LAT), and X.25 packet assembler/disassembler (PAD).
Cisco IOS Virtual Switch Command Reference	Virtual switch redundancy, high availability, and packet handling; converting between standalone and virtual switch modes; virtual switch link (VSL); Virtual Switch Link Protocol (VSLP). **Note** For information about virtual switch configuration, refer to the product-specific software configuration information for the Cisco Catalyst 6500 series switch or for the Metro Ethernet 6500 series switch.
Cisco IOS Voice Configuration Library *Cisco IOS Voice Command Reference*	Cisco IOS support for voice call control protocols, interoperability, physical and virtual interface management, and troubleshooting. The library includes documentation for IP telephony applications.
Cisco IOS VPDN Configuration Guide *Cisco IOS XE VPDN Configuration Guide* *Cisco IOS VPDN Command Reference*	Layer 2 Tunneling Protocol (L2TP) dial-out load balancing and redundancy, L2TP extended failover, L2TP security VPDN, multihop by Dialed Number Identification Service (DNIS), timer and retry enhancements for L2TP and Layer 2 Forwarding (L2F), RADIUS Attribute 82: tunnel assignment ID, shell-based authentication of VPDN users, tunnel authentication via RADIUS on tunnel terminator.
Cisco IOS Wide-Area Networking Configuration Guide *Cisco IOS XE Wide-Area Networking Configuration Guide* *Cisco IOS Wide-Area Networking Command Reference*	Frame Relay, Layer 2 Tunneling Protocol Version 3 (L2TPv3), Link Access Procedure, Balanced (LAPB), Switched Multimegabit Data Service (SMDS), and X.25.
Cisco IOS Wireless LAN Configuration Guide *Cisco IOS Wireless LAN Command Reference*	Broadcast key rotation, IEEE 802.11x support, IEEE 802.1x authenticator, IEEE 802.1x local authentication service for Extensible Authentication Protocol-Flexible Authentication via Secure Tunneling (EAP-FAST), Multiple Basic Service Set ID (BSSID), Wi-Fi Multimedia (WMM) required elements, and Wi-Fi Protected Access (WPA).

Table 2 Cisco IOS Supplementary Documents and Resources

Document Title	Description
Cisco IOS Master Command List, All Releases	Alphabetical list of all the commands documented in all Cisco IOS releases.
Cisco IOS New, Modified, Removed, and Replaced Commands	List of all the new, modified, removed, and replaced commands for a Cisco IOS release.
Cisco IOS Software System Messages	List of Cisco IOS system messages and descriptions. System messages may indicate problems with your system; be informational only; or may help diagnose problems with communications lines, internal hardware, or the system software.
Cisco IOS Debug Command Reference	Alphabetical list of **debug** commands including brief descriptions of use, command syntax, and usage guidelines.
Release Notes and Caveats	Information about new and changed features, system requirements, and other useful information about specific software releases; information about defects in specific Cisco IOS software releases.
MIBs	Files used for network monitoring. To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator at the following URL: http://www.cisco.com/go/mibs
RFCs	Standards documents maintained by the Internet Engineering Task Force (IETF) that Cisco IOS documentation references where applicable. The full text of referenced RFCs may be obtained at the following URL: http://www.rfc-editor.org/

Additional Resources and Documentation Feedback

What's New in Cisco Product Documentation is published monthly and describes all new and revised Cisco technical documentation. The *What's New in Cisco Product Documentation* publication also provides information about obtaining the following resources:

- Technical documentation
- Cisco product security overview
- Product alerts and field notices
- Technical assistance

Cisco IOS technical documentation includes embedded feedback forms where you can rate documents and provide suggestions for improvement. Your feedback helps us improve our documentation.

Using the Command-Line Interface in Cisco IOS and Cisco IOS XE Software

Last updated: August 6, 2008

This document provides basic information about the command-line interface (CLI) in Cisco IOS and Cisco IOS XE software and how you can use some of the CLI features. This document contains the following sections:

For more information about using the CLI, see the "Using the Cisco IOS Command-Line Interface" section of the *Cisco IOS Configuration Fundamentals Configuration Guide*.

For information about the software documentation set, see the "About Cisco IOS and Cisco IOS XE Software Documentation" document.

Initially Configuring a Device

Initially configuring a device varies by platform. For information about performing an initial configuration, see the hardware installation documentation that is provided with the original packaging of the product or go to the Product Support area of Cisco.com at http://www.cisco.com/web/psa/products/index.html.

After you have performed the initial configuration and connected the device to your network, you can configure the device by using the console port or a remote access method, such as Telnet or Secure Shell (SSH), to access the CLI or by using the configuration method provided on the device, such as Security Device Manager.

Changing the Default Settings for a Console or AUX Port

There are only two changes that you can make to a console port and an AUX port:

- Change the port speed with the **config-register 0x** command. Changing the port speed is not recommended. The well-known default speed is 9600.
- Change the behavior of the port; for example, by adding a password or changing the timeout value.

Note The AUX port on the Route Processor (RP) installed in a Cisco ASR1000 series router does not serve any useful customer purpose and should be accessed only under the advisement of a customer support representative.

Using the CLI

This section describes the following topics:

Understanding Command Modes

The CLI command mode structure is hierarchical, and each mode supports a set of specific commands. This section describes the most common of the many modes that exist.

Table 1 lists common command modes with associated CLI prompts, access and exit methods, and a brief description of how each mode is used.

Table 1 CLI Command Modes

Command Mode	Access Method	Prompt	Exit Method	Mode Usage
User EXEC	Log in.	`Router>`	Issue the **logout** or **exit** command.	• Change terminal settings. • Perform basic tests. • Display device status.
Privileged EXEC	From user EXEC mode, issue the **enable** command.	`Router#`	Issue the **disable** command or the **exit** command to return to user EXEC mode.	• Issue **show** and **debug** commands. • Copy images to the device. • Reload the device. • Manage device configuration files. • Manage device file systems.
Global configuration	From privileged EXEC mode, issue the **configure terminal** command.	`Router(config)#`	Issue the **exit** command or the **end** command to return to privileged EXEC mode.	Configure the device.
Interface configuration	From global configuration mode, issue the **interface** command.	`Router(config-if)#`	Issue the **exit** command to return to global configuration mode or the **end** command to return to privileged EXEC mode.	Configure individual interfaces.
Line configuration	From global configuration mode, issue the **line vty** or **line console** command.	`Router(config-line)#`	Issue the **exit** command to return to global configuration mode or the **end** command to return to privileged EXEC mode.	Configure individual terminal lines.

Table 1 CLI Command Modes (continued)

Command Mode	Access Method	Prompt	Exit Method	Mode Usage
ROM monitor	From privileged EXEC mode, issue the **reload** command. Press the **Break** key during the first 60 seconds while the system is booting.	`rommon # >` The # symbol represents the line number and increments at each prompt.	Issue the **continue** command.	• Run as the default operating mode when a valid image cannot be loaded. • Access the fall-back procedure for loading an image when the device lacks a valid image and cannot be booted. • Perform password recovery when a CTRL-Break sequence is issued within 60 seconds of a power-on or reload event.
Diagnostic (available only on the Cisco ASR1000 series router)	The router boots or enters diagnostic mode in the following scenarios. When a Cisco IOS process or processes fail, in most scenarios the router will reload. • A user-configured access policy was configured using the **transport-map** command, which directed the user into diagnostic mode. • The router was accessed using an RP auxiliary port. • A break signal (**Ctrl-C**, **Ctrl-Shift-6**, or the **send break** command) was entered, and the router was configured to enter diagnostic mode when the break signal was received.	`Router(diag)#`	If a Cisco IOS process failure is the reason for entering diagnostic mode, the failure must be resolved and the router must be rebooted to exit diagnostic mode. If the router is in diagnostic mode because of a transport-map configuration, access the router through another port or using a method that is configured to connect to the Cisco IOS CLI. If the RP auxiliary port was used to access the router, use another port for access. Accessing the router through the auxiliary port is not useful for customer purposes.	• Inspect various states on the router, including the Cisco IOS state. • Replace or roll back the configuration. • Provide methods of restarting the Cisco IOS software or other processes. • Reboot hardware, such as the entire router, an RP, an ESP, a SIP, a SPA, or possibly other hardware components. • Transfer files into or off of the router using remote access methods such as FTP, TFTP, and SCP.

EXEC commands are not saved when the software reboots. Commands that you issue in a configuration mode can be saved to the startup configuration. If you save the running configuration to the startup configuration, these commands will execute when the software is rebooted. Global configuration mode is the highest level of configuration mode. From global configuration mode, you can enter a variety of other configuration modes, including protocol-specific modes.

ROM monitor mode is a separate mode that is used when the 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. Use the question symbol (?) to view the commands that you can use while the device is in ROM monitor mode.

```
rommon 1 > ?
alias               set and display aliases command
boot                boot up an external process
confreg             configuration register utility
cont                continue executing a downloaded image
context             display the context of a loaded image
cookie              display contents of cookie PROM in hex
.
.
.
rommon 2 >
```

The following example shows how the command prompt changes to indicate a different command mode:

```
Router> enable
Router# configure terminal
Router(config)# interface ethernet 1/1
Router(config-if)# ethernet
Router(config-line)# exit
Router(config)# end
Router#
```

Note A keyboard alternative to the **end** command is Ctrl-Z.

Using the Interactive Help Feature

The CLI includes an interactive Help feature. Table 2 describes how to use the Help feature.

Table 2 CLI Interactive Help Commands

Command	Purpose
help	Provides a brief description of the help feature in any command mode.
?	Lists all commands available for a particular command mode.
*partial command***?**	Provides a list of commands that begin with the character string (no space between the command and the question mark).
partial command<**Tab**>	Completes a partial command name (no space between the command and <Tab>).
command **?**	Lists the keywords, arguments, or both associated with the command (space between the command and the question mark).
command keyword **?**	Lists the arguments that are associated with the keyword (space between the keyword and the question mark).

The following examples show how to use the help commands:

help

```
Router> help

Help may be requested at any point in a command by entering a question mark '?'.  If
nothing matches, the help list will be empty and you must backup until entering a '?'
shows the available options.

Two styles of help are provided:

1. Full help is available when you are ready to enter a command argument (e.g. 'show ?')
and describes each possible argument.

2. Partial help is provided when an abbreviated argument is entered and you want to know
what arguments match the input (e.g. 'show pr?'.)
```

?

```
Router# ?
Exec commands:
  access-enable        Create a temporary access-List entry
  access-profile       Apply user-profile to interface
  access-template      Create a temporary access-List entry
  alps                 ALPS exec commands
  archive              manage archive files
<snip>
```

***partial command*?**

```
Router(config)# zo?
zone  zone-pair
```

***partial command*<Tab>**

```
Router(config)# we<Tab> webvpn
```

***command* ?**

```
Router(config-if)# pppoe ?
  enable        Enable pppoe
  max-sessions  Maximum PPPOE sessions
```

***command keyword* ?**

```
Router(config-if)# pppoe enable ?
  group  attach a BBA group
  <cr>
```

Understanding Command Syntax

Command syntax is the format in which a command should be entered in the CLI. Commands include the name of the command, keywords, and arguments. Keywords are alphanumeric strings that are used literally. Arguments are placeholders for values that a user must supply. Keywords and arguments may be required or optional.

Specific conventions convey information about syntax and command elements. Table 3 describes these conventions.

Table 3 CLI Syntax Conventions

Symbol/Text	Function	Notes
< > (angle brackets)	Indicate that the option is an argument.	Sometimes arguments are displayed without angle brackets.
A.B.C.D.	Indicates that you must enter a dotted decimal IP address.	Angle brackets (< >) are not always used to indicate that an IP address is an argument.
WORD (all capital letters)	Indicates that you must enter one word.	Angle brackets (< >) are not always used to indicate that a WORD is an argument.
LINE (all capital letters)	Indicates that you must enter more than one word.	Angle brackets (< >) are not always used to indicate that a LINE is an argument.
<cr> (carriage return)	Indicates the end of the list of available keywords and arguments, and also indicates when keywords and arguments are optional. When <cr> is the only option, you have reached the end of the branch or the end of the command if the command has only one branch.	—

The following examples show syntax conventions:

```
Router(config)# ethernet cfm domain ?
  WORD  domain name
Router(config)# ethernet cfm domain dname ?
  level
Router(config)# ethernet cfm domain dname level ?
  <0-7>  maintenance level number
Router(config)# ethernet cfm domain dname level 7 ?
  <cr>
Router(config)# snmp-server file-transfer access-group 10 ?
  protocol  protocol options
  <cr>
Router(config)# logging host ?
  Hostname or A.B.C.D  IP address of the syslog server
  ipv6                 Configure IPv6 syslog server
Router(config)# snmp-server file-transfer access-group 10 ?
  protocol  protocol options
  <cr>
```

Understanding Enable and Enable Secret Passwords

Some privileged EXEC commands are used for actions that impact the system, and it is recommended that you set a password for these commands to prevent unauthorized use. Two types of passwords, enable (not encrypted) and enable secret (encrypted), can be set. The following commands set these passwords and are issued in global configuration mode:

- **enable** *password*
- **enable secret** *password*

Using an enable secret password is recommended because it is encrypted and more secure than the enable password. When you use an enable secret password, text is encrypted (unreadable) before it is written to the config.text file. When you use an enable password, the text is written as entered (readable) to the config.text file.

Each type of password is case sensitive, can contain from 1 to 25 uppercase and lowercase alphanumeric characters, and can start with a number. Spaces are also valid password characters; for example, "two words" is a valid password. Leading spaces are ignored, but trailing spaces are recognized.

Note Both password commands have numeric keywords that are single integer values. If you choose a number for the first character of your password followed by a space, the system will read the number as if it were the numeric keyword and not as part of your password.

When both passwords are set, the enable secret password takes precedence over the enable password.

To remove a password, use the **no** form of the commands: **no enable** *password* or **no enable secret** *password*.

For more information about password recovery procedures for Cisco products, see http://www.cisco.com/en/US/products/sw/iosswrel/ps1831/products_tech_note09186a00801746e6.shtml.

Using the Command History Feature

The CLI command history feature saves the commands you enter during a session in a command history buffer. The default number of commands saved is 10, but the number is configurable within the range of 0 to 256. This command history feature is particularly useful for recalling long or complex commands.

To change the number of commands saved in the history buffer for a terminal session, issue the **terminal history size** command:

```
Router# terminal history size num
```

A command history buffer is also available in line configuration mode with the same default and configuration options. To set the command history buffer size for a terminal session in line configuration mode, issue the **history** command:

```
Router(config-line)# history [size num]
```

To recall commands from the history buffer, use the following methods:

- Press Ctrl-P or the up arrow key—Recalls commands beginning with the most recent command. Repeat the key sequence to recall successively older commands.

- Press Ctrl-N or the down arrow key—Recalls the most recent commands in the history buffer after they have been recalled using Ctrl-P or the up arrow key. Repeat the key sequence to recall successively more recent commands.

Note The arrow keys function only on ANSI-compatible terminals such as the VT100.

- Issue the **show history** command in user EXEC or privileged EXEC mode—Lists the most recent commands that you entered. The number of commands that are displayed is determined by the setting of the **terminal history size** and **history** commands.

  The CLI command history feature is enabled by default. To disable this feature for a terminal session, issue the **terminal no history** command in user EXEC or privileged EXEC mode or the **no history** command in line configuration mode.

Abbreviating Commands

Typing a complete command name is not always required for the command to execute. The CLI recognizes an abbreviated command when the abbreviation contains enough characters to uniquely identify the command. For example, the **show version** command can be abbreviated as **sh ver**. It cannot be abbreviated as **s ver** because **s** could mean **show**, **set**, or **systat**. The **sh v** abbreviation also is not valid because the **show** command has **vrrp** as a keyword in addition to **version**. (Command and keyword examples from Cisco IOS Release 12.4(13)T.)

Using Aliases for CLI Commands

To save time and the repetition of entering the same command multiple times, you can use a command alias. An alias can be configured to do anything that can be done at the command line, but an alias cannot move between modes, type in passwords, or perform any interactive functions.

Table 4 shows the default command aliases.

Table 4 Default Command Aliases

Command Alias	Original Command
h	help
lo	logout
p	ping
s	show
u or **un**	undebug
w	where

To create a command alias, issue the **alias** command in global configuration mode. The syntax of the command is **alias** *mode command-alias original-command*. Following are some examples:

- Router(config)# **alias exec prt partition**—privileged EXEC mode
- Router(config)# **alias configure sb source-bridge**—global configuration mode
- Router(config)# **alias interface rl rate-limit**—interface configuration mode

To view both default and user-created aliases, issue the **show alias** command.

For more information about the **alias** command, see http://www.cisco.com/en/US/docs/ios/fundamentals/command/reference/cf_book.html.

Using the no and default Forms of Commands

Most configuration commands have a **no** form that is used to reset a command to its default value or disable a feature or function. For example, the **ip routing** command is enabled by default. To disable this command, you would issue the **no ip routing** command. To re-enable IP routing, you would issue the **ip routing** command.

Configuration commands may also have a **default** form, which returns the command settings to their default values. For commands that are disabled by default, using the **default** form has the same effect as using the **no** form of the command. For commands that are enabled by default and have default settings, the **default** form enables the command and returns the settings to their default values.

The **no** and **default** forms of commands are described in the command pages of command references.

Using the debug Command

A **debug** command produces extensive output that helps you troubleshoot problems in your network. These commands are available for many features and functions within Cisco IOS and Cisco IOS XE software. Some **debug** commands are **debug all**, **debug aaa accounting**, and **debug mpls packets**. To use **debug** commands during a Telnet session with a device, you must first enter the **terminal monitor** command. To turn off debugging completely, you must enter the **undebug all** command.

For more information about **debug** commands, see the *Cisco IOS Debug Command Reference* at http://www.cisco.com/en/US/docs/ios/debug/command/reference/db_book.html.

Caution Debugging is a high priority and high CPU utilization process that can render your device unusable. Use **debug** commands only to troubleshoot specific problems. The best times to run debugging are during periods of low network traffic and when few users are interacting with the network. Debugging during these periods decreases the likelihood that the **debug** command processing overhead will affect network performance or user access or response times.

Filtering Output Using Output Modifiers

Many commands produce lengthy output that may use several screens to display. Using output modifiers, you can filter this output to show only the information that you want to see.

Three output modifiers are available and are described as follows:

- **begin** *regular expression*—Displays the first line in which a match of the regular expression is found and all lines that follow.
- **include** *regular expression*—Displays all lines in which a match of the regular expression is found.
- **exclude** *regular expression*—Displays all lines except those in which a match of the regular expression is found.

To use one of these output modifiers, type the command followed by the pipe symbol (|), the modifier, and the regular expression that you want to search for or filter. A regular expression is a case-sensitive alphanumeric pattern. It can be a single character or number, a phrase, or a more complex string.

The following example illustrates how to filter output of the **show interface** command to display only lines that include the expression "protocol."

```
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
```

Understanding CLI Error Messages

You may encounter some error messages while using the CLI. Table 5 shows the common CLI error messages.

Table 5 Common CLI Error Messages

Error Message	Meaning	How to Get Help
% Ambiguous command: "show con"	You did not enter enough characters for the command to be recognized.	Reenter the command followed by a space and a question mark (?). The keywords that you are allowed to enter for the command appear.
% Incomplete command.	You did not enter all the keywords or values required by the command.	Reenter the command followed by a space and a question mark (?). The keywords that you are allowed to enter for the command appear.
% Invalid input detected at "^" marker.	You entered the command incorrectly. The caret (^) marks the point of the error.	Enter a question mark (?) to display all the commands that are available in this command mode. The keywords that you are allowed to enter for the command appear.

For more system error messages, see the following documents:

- *Cisco IOS Release 12.2SR System Message Guide*
- *Cisco IOS System Messages, Volume 1 of 2* (Cisco IOS Release 12.4)
- *Cisco IOS System Messages, Volume 2 of 2* (Cisco IOS Release 12.4)

Saving Changes to a Configuration

To save changes that you made to the configuration of a device, you must issue the **copy running-config startup-config** command or the **copy system:running-config nvram:startup-config** command. When you issue these commands, the configuration changes that you made are saved to the startup configuration and saved when the software reloads or power to the device is turned off or interrupted. The following example shows the syntax of the **copy running-config startup-config** command:

```
Router# copy running-config startup-config
Destination filename [startup-config]?
```

You press Enter to accept the startup-config filename (the default), or type a new filename and then press Enter to accept that name. The following output is displayed indicating that the configuration was saved:

```
Building configuration...
[OK]
Router#
```

On most platforms, the configuration is saved to NVRAM. On platforms with a Class A flash file system, the configuration is saved to the location specified by the CONFIG_FILE environment variable. The CONFIG_FILE variable defaults to NVRAM.

Additional Information

- "Using the Cisco IOS Command-Line Interface" section of the *Cisco IOS Configuration Fundamentals Configuration Guide*:

  http://www.cisco.com/en/US/docs/ios/fundamentals/configuration/guide/cf_cli-basics.html

  or

  "Using Cisco IOS XE Software" chapter of the *Cisco ASR1000 Series Aggregation Services Routers Software Configuration Guide*:

  http://www.cisco.com/en/US/docs/routers/asr1000/configuration/guide/chassis/using_cli.html
- Cisco Product Support Resources

  http://www.cisco.com/web/psa/products/index.html
- Support area on Cisco.com (also search for documentation by task or product)

  http://www.cisco.com/en/US/support/index.html
- *White Paper: Cisco IOS Reference Guide*

  http://www.cisco.com/en/US/products/sw/iosswrel/ps1828/products_white_paper09186a008018305e.shtml
- Software Download Center (downloads; tools; licensing, registration, advisory, and general information) (requires Cisco.com User ID and password)

  http://www.cisco.com/kobayashi/sw-center/
- Error Message Decoder, a tool to help you research and resolve error messages for Cisco IOS software

  http://www.cisco.com/pcgi-bin/Support/Errordecoder/index.cgi

- Command Lookup Tool, a tool to help you find detailed descriptions of Cisco IOS commands (requires Cisco.com user ID and password)

  http://tools.cisco.com/Support/CLILookup

- Output Interpreter, a troubleshooting tool that analyzes command output of supported **show** commands

  https://www.cisco.com/pcgi-bin/Support/OutputInterpreter/home.pl\

Cisco IOS Switching Paths Overview

First Published: February 11, 2008
Last Updated: May 5, 2008

This module provides an overview of the switching paths that can be configured on Cisco IOS devices.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for the Cisco IOS Switching Paths Overview" section on page 10.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

Information About IOS Switching Paths

This section provides information about Cisco IOS switching paths and contains the following concepts:

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

Basic Router Platform Architecture and Processes

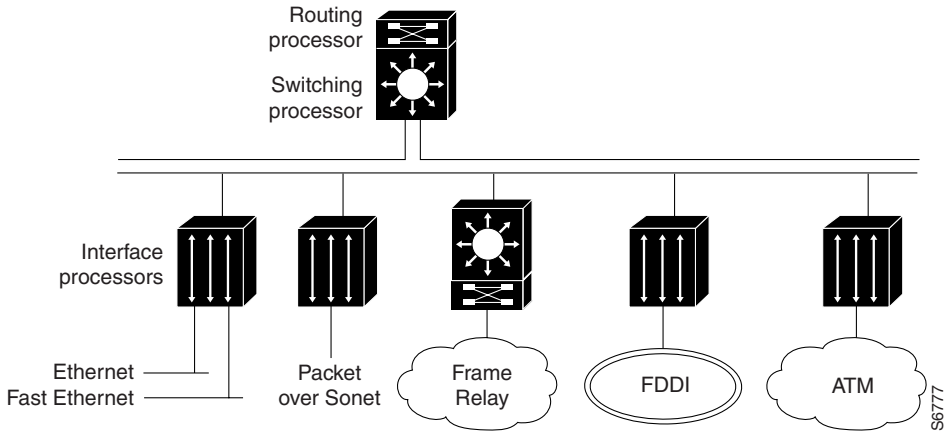
To understand how switching works, it helps to first understand the basic router architecture and where various processes occur in the router.

Note IP unicast fast switching is not supported is not supported on Cisco IOS 12.2S, 12.2SB, 12.2SR, and 12.2SX releases.

Fast switching is enabled by default on all interfaces that support fast switching. If you have a situation where you need to disable fast switching and fall back to the process-switching path, understanding how various processes affect the router and where they occur will help you determine your alternatives. This understanding is especially helpful when you are troubleshooting traffic problems or need to process packets that require special handling. Some diagnostic or control resources are not compatible with fast switching or come at the expense of processing and switching efficiency. Understanding the effects of those resources can help you minimize their effect on network performance.

Figure 2 illustrates a possible internal configuration of a Cisco 7500 series router. In this configuration, the Cisco 7500 series router has an integrated Route Switch Processor (RSP) and uses *route caching* to forward packets. The Cisco 7500 series router also uses Versatile Interface Processors (VIPs), a RISC-based interface processor that receives and caches routing information from the RSP. The VIP card uses the route cache to make switching decisions locally, which relieves the RSP of involvement and speeds overall throughput. This type of switching is called distributed switching. Multiple VIP cards can be installed in one router.

Figure 1 Basic Router Architecture



Cisco Routing and Switching Processes

The routing, or forwarding, function comprises two interrelated processes to move information in the network:

- Making a routing decision by routing
- Moving packets to the next hop destination by switching

Cisco IOS platforms perform both routing and switching, and there are several types of each:

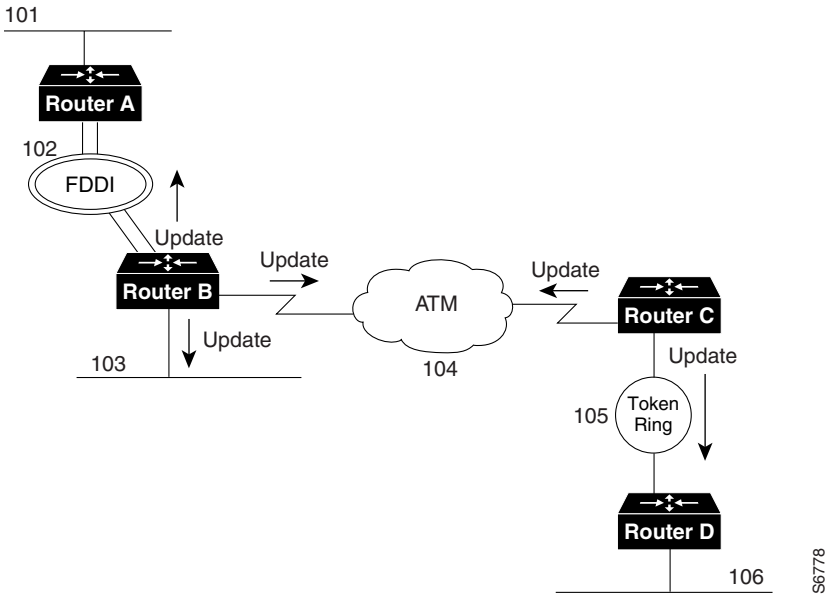
Routing Processes

The routing process assesses the source and destination of traffic based on knowledge of network conditions. Routing functions identify the best path to use for moving the traffic to the destination out one or more of the router interfaces. The routing decision is based on various criteria such as link speed, topological distance, and protocol. Each protocol maintains its own routing information.

Routing is more processing intensive and has higher latency than switching as it determines path and next hop considerations. The first packet routed requires a lookup in the routing table to determine the route. The route cache is populated after the first packet is routed by the route-table lookup. Subsequent traffic for the same destination is switched using the routing information stored in the route cache.

Figure 3 illustrates the basic routing process.

Figure 2 The Routing Process



A router sends routing updates out each of its interfaces that are configured for a particular protocol. It also receives routing updates from other attached routers. From these received updates and its knowledge of attached networks, it builds a map of the network topology.

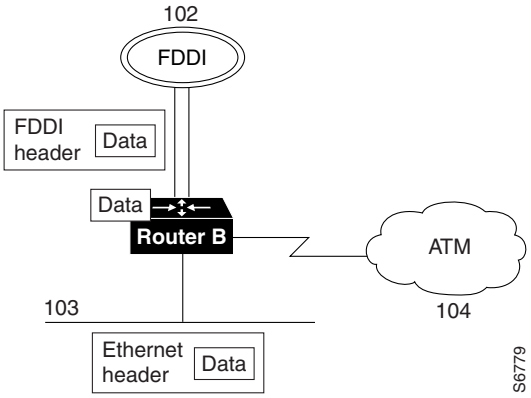
Selective Packet Discard Manages Routing Protocol Packets During Overload Conditions

When in severe overload conditions, routers that cannot keep up with the incoming packet stream must drop packets. If no intelligence is applied to choosing which packets to discard, the stability of routing protocols is impacted. The Selective Packet Discard (SPD) feature applies some simple choices to selectively discard packets likely to be unimportant for routing and interface stability. SPD is enabled by default; there are no commands or configuration tasks required.

Switching Processes

Through the switching process, the router determines the next hop toward the destination address. Switching moves traffic from an input interface to one or more output interfaces. Switching is optimized and has lower latency than routing because it can move packets, frames, or cells from buffer to buffer with simpler determination of the source and destination of the traffic. It saves resources because it does not involve extra lookups. Figure 4 illustrates the basic switching process.

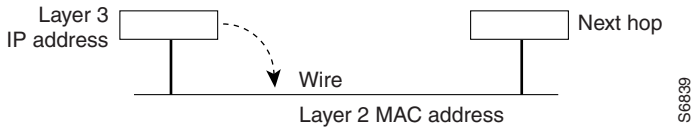
Figure 3 The Switching Process



In Figure 4, packets are received on the Fast Ethernet interface and destined for the FDDI interface. Based on information in the packet header and destination information stored in the routing table, the router determines the destination interface. It looks in the routing table of the protocol to discover the destination interface that services the destination address of the packet.

The destination address is stored in tables such as ARP tables for IP or AARP tables for AppleTalk. If there is no entry for the destination, the router will either drop the packet (and inform the user if the protocol provides that feature) or discover the destination address by some other address resolution process, such as through ARP. Layer 3 IP addressing information is mapped to the Layer 2 MAC address for the next hop. Figure 5 illustrates the mapping that occurs to determine the next hop.

Figure 4 Layer 3-to-Layer 2 Mapping



Basic Switching Paths

Basic switching paths are described in the following sections:

Process Switching

In process switching the first packet is copied to the system buffer. The router looks up the Layer 3 network address in the routing table and initializes the fast-switch cache. The frame is rewritten with the destination address and sent to the outgoing interface that services that destination. Subsequent packets for that destination are sent by the same switching path. The route processor computes the cyclical redundancy check (CRC).

Fast Switching

When packets are fast switched, the first packet is copied to packet memory and the destination network or host is found in the fast-switching cache. The frame is rewritten and sent to the outgoing interface that services the destination. Subsequent packets for the same destination use the same switching path. The interface processor computes the CRC. Fast switching is described in the "Configuring Fast Switching" chapter.

Note IP unicast fast switching is not supported is not supported on Cisco IOS 12.2S releases.

Cisco Express Forwarding Switching

When Cisco Express Forwarding mode is enabled, the Cisco Express Forwarding Forwarding Information Base (FIB) and adjacency tables reside on the Route Processor (RP), and the RP performs the express forwarding. You can use Cisco Express Forwarding mode when line cards are not available for Cisco Express Forwarding switching or when you need to use features not compatible with distributed Cisco Express Forwarding switching. For information on configuring Cisco Express Forwarding, see the "Cisco Express Forwarding Overview" chapters.

Note Beginning with Cisco IOS Release 12.0, Cisco Express Forwarding is the preferred and default switching path. NetFlow switching has been integrated into Cisco Express Forwarding switching. For information on NetFlow switching, see the "Cisco Express Forwarding Overview" chapter and the "Configuring Cisco Express Forwarding" chapter later in this publication.

Distributed Cisco Express Forwarding Switching

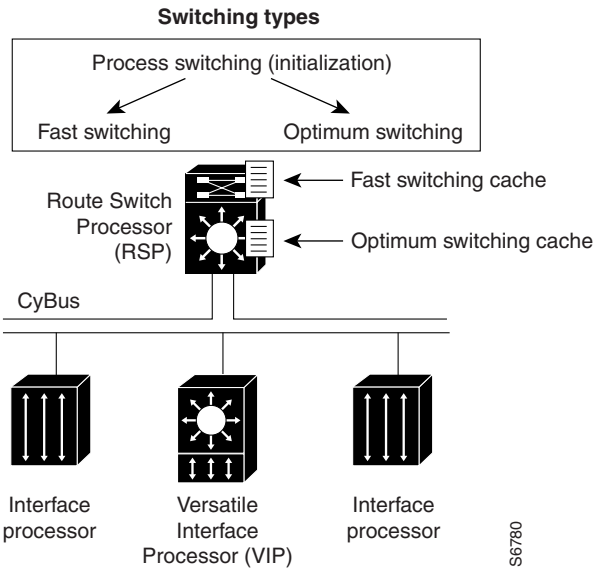
In distributed switching, the switching process occurs on VIP and other interface cards that support switching. When distributed Cisco Express Forwarding is enabled, line cards, such as VIP line cards or GSR line cards, maintain an identical copy of the FIB and adjacency tables. The line cards perform the express forwarding between port adapters, relieving the RSP of involvement in the switching operation. distributed Cisco Express Forwarding uses an Inter Process Communication (IPC) mechanism to ensure synchronization of FIBs and adjacency tables on the RP and line cards.

For model numbers and hardware compatibility information, refer to the *Cisco Product Catalog*. For information on configuring distributed Cisco Express Forwarding, see the "Configuring Cisco Express Forwarding" chapters.

For information on configuring Multicast Distributed Switching (MDS), see the "Configuring Multicast Distributed Switching" chapter.

Figure 6 illustrates the distributed switching process on the Cisco 7500 series.

Figure 5 Distributed Switching on Cisco 7500 Series Routers



The VIP card installed in this router maintains a copy of the routing cache information needed to forward packets. Because the VIP card has the routing information it needs, it performs the switching locally, making the packet forwarding much faster. Router throughput is increased linearly based on the number of VIP cards installed in the router.

Platform and Switching Path Correlation

Depending on the routing platform you are using, availability and default implementations of switching paths varies. Table 3 shows the correlation between Cisco IOS switching paths and routing platforms.

Table 1 Switching Paths on Cisco 7200 and Cisco 7500 Series Routers

Switching Path	Cisco 7200 Series	Cisco 7500 Series	Comments	Configuration Command
Process switching	Yes	Yes	Initializes switching caches	**no** *protocol* **route-cache**
Fast switching	Yes	Yes	Default (except for IP unicast)	*protocol* **route-cache**
Cisco Express Forwarding switching	Yes	Yes	Default for IP	*protocol* **route-cache cef**
distributed Cisco Express Forwarding switching	No	Yes	Using second-generation VIP line cards	*protocol* **route-cache cef distributed**

Features That Affect Performance

Performance is derived from the switching mechanism you are using. Some Cisco IOS features require special handling and cannot be switched until the additional processing they require has been performed. This special handling is not processing that the interface processors can do. Because these features require additional processing, they affect switching performance. These features include the following:

- Queueing When Network Congestion Occurs, page 7
- Random Early Detection for Congestion Avoidance, page 8
- Compression Options Depending on Protocol You Are Using, page 8
- Filtering Using Access Lists, page 8
- Encryption Added For Security, page 8
- Accounting Feature Based on Protocol Used, page 8

For information on Quality of Service (QoS) performance, refer to the *Cisco IOS Quality of Service Solutions Configuration Guide*.

Queueing When Network Congestion Occurs

Queueing occurs when network congestion occurs. When traffic is moving well within the network, packets are sent as they arrive at the interface. Cisco IOS software implements four different queueing algorithms as follows:

- FIFO queueing—Packets are forwarded in the same order in which they arrive at the interface.
- Priority queueing (PQ)—Packets are forwarded based on an assigned priority. You can create priority lists and groups to define rules for assigning packets to priority queues.

- Custom queueing (CQ)—You can control a percentage of interface bandwidth for specified traffic by creating protocol queue lists and custom queue lists.
- Weighted fair queueing (WFQ)—WFQ provides automatic traffic priority management. Low-bandwidth sessions have priority over high-bandwidth sessions. High-bandwidth sessions are assigned weights. WFQ is the default for interfaces slower than 2.048 Mbps.

Random Early Detection for Congestion Avoidance

Random Early Detection (RED) is designed for congestion avoidance. Traffic is prioritized based on type of service (ToS), or precedence. This feature is available on T3, OC-3, and ATM interfaces.

Compression Options Depending on Protocol You Are Using

Depending on the protocol you are using, various compression options are available in Cisco IOS software. Refer to the Cisco IOS configuration guide for the protocol you are using to learn compression options available.

Filtering Using Access Lists

You can define access lists to control access to or from a router for a number of services. You could, for example, define an access list to prevent packets with a certain IP address from leaving a particular interface on a router. How access lists are used depends on the protocol. For information on access lists, refer to the appropriate Cisco IOS configuration guide for the protocol you are using.

Encryption Added For Security

Encryption algorithms are applied to data to alter its appearance, making it incomprehensible to those not authorized to see the data. For information about encryption features available with the Cisco IOS software, refer to the *Cisco IOS Security Configuration Guide*.

Accounting Feature Based on Protocol Used

You can configure accounting features to collect network data related to resource usage. The information you collect (in the form of statistics) can be used for billing, chargeback, and planning resource usage. Refer to the appropriate Cisco IOS configuration guide for the protocol you are using for information regarding accounting features you can use.

How to Configure Cisco IOS Switching Paths Overview

Cisco IOS switching path overview has no configuration tasks.

Configuration Examples for Cisco IOS Switching Paths Overview

Cisco IOS switching path overview has no configuration tasks and therefore no configuration examples.

Additional References

The following sections provide references related to Cisco IOS Switching Paths.

Related Documents

Related Topic	Document Title
List of the features documented in the Cisco Express Forwarding modules	*Cisco Express Forwarding Features Roadmap*
Overview of the Cisco Express Forwarding feature	*Cisco Express Forwarding Overview*
Tasks for enabling or disabling Cisco Express Forwarding or distributed Cisco Express Forwarding	*Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding to Customize Switching and Forwarding for Dynamic Networks*
Tasks for configuring a load-balancing scheme for Cisco Express Forwarding	*Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic*
Tasks for configuring Cisco Express Forwarding consistency checkers	*Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards*
Tasks for configuring epochs for Cisco Express Forwarding tables	*Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables*
Tasks for configuring and verifying Cisco Express Forwarding network accounting	*Configuring Cisco Express Forwarding Network Accounting*
Tasks for customizing the display of recorded Cisco Express Forwarding events	*Customizing the Display of Recorded Cisco Express Forwarding Events*
Tasks for configuring fast switching	*Configuring Fast Switching*
Tasks for configuring Multicast Distributed Switching	*Configuring Multicast Distributed Switching*

Standards

Standard	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Feature Information for the Cisco IOS Switching Paths Overview

Table 2 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Releases 12.2(1) or 12.0(3) or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the "Cisco IOS IP Switching Features Roadmap" module.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 2 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 2 Feature Information for Cisco IOS Switching Paths Overview

Feature Name	Releases	Feature Information
This table is intentionally left blank because no features were introduced or modified in Cisco IOS Release 12.2(1) or later. This table will be updated when feature information is added to this module.	—	—

Glossary

adjacency—A relationship formed between selected neighboring routers and end nodes for the purpose of exchanging routing information. Adjacency is based upon the use of a common media segment by the routers and nodes involved.

Cisco Express Forwarding—A Layer 3 switching technology. Cisco Express Forwarding can also refer to central Cisco Express Forwarding mode, one of two modes of Cisco Express Forwarding operation. Cisco Express Forwarding enables a Route Processor (RP) to perform express forwarding. Distributed Cisco Express Forwarding is the other mode of Cisco Express Forwarding operation.

distributed Cisco Express Forwarding—A type of Cisco Express Forwarding switching in which line cards (such as Versatile Interface Processor (VIP) line cards) maintain identical copies of the forwarding information base (FIB) and adjacency tables. The line cards perform the express forwarding between port adapters; this relieves the Route Switch Processor of involvement in the switching operation.

FIB—forwarding information base. A component of Cisco Express Forwarding. The router uses the FIB lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The router maintains a mirror image of the forwarding information in an IP routing table.

IPC—interprocess communication. The mechanism that enables the distribution of Cisco Express Forwarding tables from the Route Switch Processor (RSP) to the line card when the router is operating in distributed Cisco Express Forwarding mode.

LIB—label information base. A database used by a label switch router (LSR) to store labels learned from other LSRs, as well as labels assigned by the local LSR.

line card—A general term for an interface processor that can be used in various Cisco products. For example, a Versatile Interface Processor (VIP) is a line card for the Cisco 7500 series router.

MPLS—Multiprotocol Label Switching. An emerging industry standard for the forwarding of packets along the normal routing paths (sometimes called MPLS hop-by-hop forwarding).

RP—Route Processor. The processor module in the Cisco 7000 series routers that contains the CPU, system software, and most of the memory components that are used in the router. It is sometimes called a supervisory processor.

VIP—Versatile Interface Processor. An interface card used in Cisco 7000 and Cisco 7500 series routers. The VIP provides multilayer switching and runs Cisco IOS.

VPN—Virtual Private Network. The result of a router configuration that enables IP traffic to use tunneling to travel securely over a public TCP/IP network.

VRF—A Virtual Private Network (VPN) routing/forwarding instance. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table. In general, a VRF includes the routing information that defines a customer VPN site that is attached to a PE router.

Cisco Express Forwarding

Cisco Express Forwarding Features Roadmap

First Published: May 2, 2005
Last Updated: February 11, 2008

This feature roadmap lists the Cisco IOS features documented in the Cisco Express Forwarding modules in the *Cisco IOS IP Switching Configuration Guide* and maps them to the documents in which they appear. The roadmap is organized so that you can select your release train and see the features in that release. Find the feature name you are searching for and click on the URL in the "Where Documented" column to access the document containing that feature.

Feature and Release Support

Table 1 lists Cisco Express Forwarding feature support for the following Cisco IOS software release trains:

- Cisco IOS Release 12.2S
- Cisco IOS Release 12.2SB
- Cisco IOS Release 12.2SR
- Cisco IOS Release 12.2SX
- Cisco IOS Releases 12.2T, 12.3, 12.3T, 12.4, and 12.4T

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 1 lists the most recent release of each software train first and the features in alphabetical order within the release.

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

Table 1 Supported Cisco Express Forwarding Features

Release	Feature Name	Feature Description	Where Documented
Cisco IOS Release 12.2S			
12.2(25)S	Cisco Express Forwarding: Command Changes	This feature details changes to command that are required to support Cisco Express Forwarding. In Cisco IOS Releases 12.2(25)S, 12.2(28)SB, 12.2(33)SRA and 12.2(33)SXH, Cisco Express Forwarding has been updated to support new features and new hardware. These updates enable Cisco Express Forwarding to operate with the Multiprotocol Label Switching (MPLS) High Availability (HA) applications and the MPLS Forwarding Infrastructure (MFI).	"Cisco Express Forwarding: Command Changes"
Cisco IOS Release 12.2SB			
12.2(31)SB2	Cisco Express Forwarding—SNMP CEF-MIB Support	The Cisco Express Forwarding—SNMP CEF-MIB Support feature introduces the CISCO-CEF-MIB that allows management applications through the use of the Simple Network Management Protocol (SNMP) to configure and monitor Cisco Express Forwarding operational data and to provide notification when Cisco Express Forwarding encounters specific configured events. This module describes how to use the CISCO-CEF-MIB to manage and monitor objects related to Cisco Express Forwarding operation.	"Cisco Express Forwarding—SNMP CEF-MIB Support"
12.2(28)SB	Cisco Express Forwarding: Command Changes	This feature details changes to command that are required to support Cisco Express Forwarding. In Cisco IOS Releases 12.2(25)S, 12.2(28)SB, 12.2(33)SRA and 12.2(33)SXH, Cisco Express Forwarding has been updated to support new features and new hardware. These updates enable Cisco Express Forwarding to operate with the Multiprotocol Label Switching (MPLS) High Availability (HA) applications and the MPLS Forwarding Infrastructure (MFI).	"Cisco Express Forwarding: Command Changes"

Table 1 Supported Cisco Express Forwarding Features (continued)

Release	Feature Name	Feature Description	Where Documented
Cisco IOS Release 12.2SR			
12.2(33)SRC	Cisco Express Forwarding—SNMP CEF-MIB Support	The Cisco Express Forwarding—SNMP CEF-MIB Support feature introduces the CISCO-CEF-MIB that allows management applications through the use of the Simple Network Management Protocol (SNMP) to configure and monitor Cisco Express Forwarding operational data and to provide notification when Cisco Express Forwarding encounters specific configured events. This module describes how to use the CISCO-CEF-MIB to manage and monitor objects related to Cisco Express Forwarding operation.	"Cisco Express Forwarding—SNMP CEF-MIB Support"
12/2(33)SRA	Cisco Express Forwarding: Command Changes	This feature details changes to command that are required to support Cisco Express Forwarding. In Cisco IOS Releases 12.2(25)S, 12.2(28)SB, 12.2(33)SRA and 12.2(33)SXH, Cisco Express Forwarding has been updated to support new features and new hardware. These updates enable Cisco Express Forwarding to operate with the Multiprotocol Label Switching (MPLS) High Availability (HA) applications and the MPLS Forwarding Infrastructure (MFI).	"Cisco Express Forwarding: Command Changes"
Cisco IOS Release 12.2SX			
12.2(33)SXH	Cisco Express Forwarding: Command Changes	This feature details changes to command that are required to support Cisco Express Forwarding. In Cisco IOS Releases 12.2(25)S, 12.2(28)SB, 12.2(33)SRA and 12.2(33)SXH, Cisco Express Forwarding has been updated to support new features and new hardware. These updates enable Cisco Express Forwarding to operate with the Multiprotocol Label Switching (MPLS) High Availability (HA) applications and the MPLS Forwarding Infrastructure (MFI).	"Cisco Express Forwarding: Command Changes"
Cisco IOS Releases 12.2T, 12.3, 12.3T, 12.4, and 12.4T			

Table 1 Supported Cisco Express Forwarding Features (continued)

Release	Feature Name	Feature Description	Where Documented
12.4(20)T	Cisco Express Forwarding Enhancements: Removal of IP Fast Switching and Introduction of CLI Changes	The purpose of this document is to describe the changes based on the Cisco Express Forwarding infrastructure scalability enhancements implemented to adapt to the evolution of the Internet and to support new platforms and features. The changes are the removal of IP fast switching and the introduction of commands line interface (CLI) modifications. This document lists Cisco Express Forwarding CLI commands that are removed, replaced, new, and changed. The document lists and illustrates new commands, changed commands, and related command that are unchanged, to help you transition to the new CLI format. Enhancements to Cisco Express Forwarding enable it to operate with the Multiprotocol Label Switching (MPLS) Forwarding Infrastructure (MFI) and guarantees consistency between Cisco IOS release trains. Cisco Express Forwarding infrastructure changes were introduced and implemented in the Cisco IOS 12.2(25)S-based releases and added for T releases in Cisco IOS Release 12.4(20)T.	"Cisco Express Forwarding Enhancements: Removal of IP Fast Switching and Introduction of CLI Changes"
	Cisco Express Forwarding: Command Changes	This feature details changes to command that are required to support Cisco Express Forwarding. In Cisco IOS Releases 12.2(25)S, 12.2(28)SB, 12.2(33)SRA and 12.2(33)SXH, Cisco Express Forwarding has been updated to support new features and new hardware. These updates enable Cisco Express Forwarding to operate with the Multiprotocol Label Switching (MPLS) High Availability (HA) applications and the MPLS Forwarding Infrastructure (MFI).	"Cisco Express Forwarding: Command Changes"
	Cisco Express Forwarding—SNMP CEF-MIB Support	The Cisco Express Forwarding—SNMP CEF-MIB Support feature introduces the CISCO-CEF-MIB that allows management applications through the use of the Simple Network Management Protocol (SNMP) to configure and monitor Cisco Express Forwarding operational data and to provide notification when Cisco Express Forwarding encounters specific configured events. This module describes how to use the CISCO-CEF-MIB to manage and monitor objects related to Cisco Express Forwarding operation.	"Cisco Express Forwarding—SNMP CEF-MIB Support"

Table 1 Supported Cisco Express Forwarding Features (continued)

Release	Feature Name	Feature Description	Where Documented
12.2(8)T	CEF-Switched Multipoint GRE Tunnels	This feature enables Cisco Express Forwarding 1switching of IP traffic to and from multipoint generic routing encapsulation (GRE) tunnels. Prior to the introduction of this feature, only process switching was available for multipoint GRE tunnels.	"Cisco Express Forwarding Overview"
12.2(8)T	Nonstop Forwarding Enhanced FIB Refresh	This feature allows you to clear the forwarding table on demand and to continue forwarding using the old entries in the table while the new forwarding table is being built.	"Configuring Epochs to Clear and Rebuild CEF and Adjacency Tables"

Cisco Express Forwarding Overview

First Published: May 2, 2005
Last Updated: June 11, 2008

This module contains an overview of the Cisco Express Forwarding feature. Cisco Express Forwarding is an advanced Layer 3 IP switching technology. It optimizes network performance and scalability for all kinds of networks: those that carry small amounts of traffic and those that carry large amounts of traffic in complex patterns, such as the Internet and networks characterized by intensive web-based spplications or interactive sessions.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Cisco Express Forwarding Overview" section on page 13.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

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

Information About Cisco Express Forwarding

Before using Cisco Express Forwarding or distributed Cisco Express Forwarding, you should understand the following:

Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding

Cisco Express Forwarding is enabled by default on most Cisco platforms running Cisco IOS software Release12.0 or later. When Cisco Express Forwarding is enabled on a router, the Route Processor (RP) performs the express forwarding.

To find out if Cisco Express Forwarding is enabled on your platform, enter the **show ip cef** command. If Cisco Express Forwarding is enabled, you receive output that looks like this:

```
Router# show ip cef

Prefix              Next Hop            Interface
[...]
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
                    192.168.101.1       FastEthernet6/1
[...]
```

If Cisco Express Forwarding is not enabled on your platform, the output for the **show ip cef** command looks like this:

```
Router# show ip cef

%CEF not running
```

Distributed Cisco Express Forwarding is enabled by default on the Catalyst 6500 series switch, the Cisco 7500 series router, and the Cisco 12000 Series Internet Router. When distributed Cisco Express Forwarding is enabled on your platform, the line cards perform the express forwarding.

If Cisco Express Forwarding is not enabled on your platform, use the **ip cef** command to enable (central) Cisco Express Forwarding or the **ip cef distributed** command to enable distributed Cisco Express Forwarding.

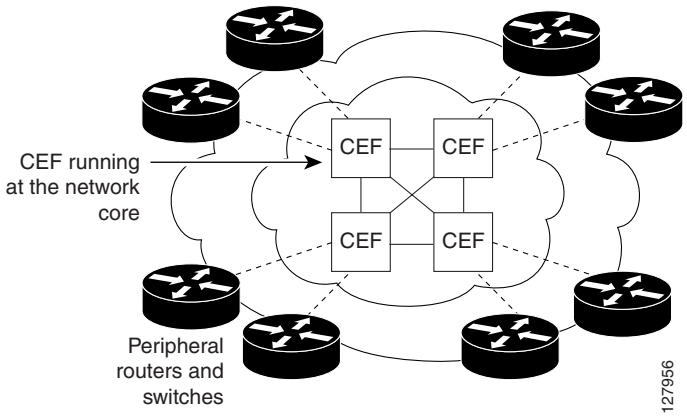
Cisco Express Forwarding Benefits: Improved Performance, Scalability, and Resilience

Cisco Express Forwarding offers the following benefits:

- Improved performance—Cisco Express Forwarding is less CPU-intensive than fast switching route caching. As a result, more CPU processing power can be dedicated to Layer 3 services such as quality of service (QoS) and encryption.
- Scalability—Cisco Express Forwarding offers full switching capacity at each line card when distributed Cisco Express Forwarding mode is active. Distributed Cisco Express Forwarding is a distributed switching mechanism that scales linearly with the number of interface cards and the bandwidth installed in the router.
- Resilience—Cisco Express Forwarding offers an unprecedented level of switching consistency and stability in large dynamic networks. In dynamic networks, fast-switched cache entries are frequently invalidated by routing changes. These changes can cause traffic to be process-switched through use of the routing table, rather than fast switched through use of the route cache. Because the forwarding information base (FIB) lookup table contains all known routes that exist in the routing table, it eliminates the need for route cache maintenance and the steps involved with fast-switch or process-switch forwarding. Cisco Express Forwarding can switch traffic more efficiently than typical demand caching schemes.

You can use Cisco Express Forwarding in any part of a network. For example, Figure 1 shows Cisco Express Forwarding being run on Cisco 12000 Series Internet routers at aggregation points at the core of a network where traffic levels are high and performance is critical.

Figure 1 Cisco Express Forwarding Example



In a typical high-capacity Internet service provider (ISP) environment, Cisco 12000 Series Internet routers function as aggregation devices at the core of the network and support links to Cisco 7500 series routers or other feeder devices. Cisco Express Forwarding in these platforms at the network core provides the performance and scalability that networks need to respond to continued growth and steadily increasing network traffic. Cisco Express Forwarding is a distributed switching mechanism that scales linearly with the number of interface cards and the bandwidth installed in the router.

Media Supported by Cisco Express Forwarding

Cisco Express Forwarding currently supports the following media:

- ATM/AAL5snap, ATM/AAL5mux, and ATM/AAL5nlpid
- Ethernet
- FDDI
- Frame Relay
- High-Level Data Link Control (HDLC)
- PPP
- Spatial Reuse Protocol (SRP)
- TokenRing
- Tunnels

Main Components of Cisco Express Forwarding Operation

Information conventionally stored in a route cache is stored in several data structures for Cisco Express Forwarding switching. The data structures provide optimized lookup for efficient packet forwarding. The two main components of Cisco Express Forwarding operation are the forwarding information base (FIB) and the adjacency tables.

The FIB is conceptually similar to a routing table or information base. A router uses this lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The FIB is updated when changes occur in the network and contains all routes known at the time. For more information, see the "FIB Overview" section on page 4.

Adjacency tables maintain Layer 2 next-hop addresses for all FIB entries. For more information, see the "Cisco Express Forwarding Adjacency Tables Overview" section on page 5.

This separation of the reachability information (in the Cisco Express Forwarding table) and the forwarding information (in the adjacency table), provides a number of benefits:

- The adjacency table can be built separately from the Cisco Express Forwarding table, allowing both to be built without any packets being process switched.
- The MAC header rewrite used to forward a packet is not stored in cache entries, so changes in a MAC header rewrite string do not require invalidation of cache entries.

FIB Overview

Cisco Express Forwarding uses a FIB to make IP destination prefix-based switching decisions.

The FIB contains the prefixes from the IP routing table structured in a way that is optimized for forwarding. When routing or topology changes occur in the network, the IP routing table is updated, and those changes are reflected in the FIB. The FIB maintains next-hop address information based on the information in the IP routing table.

Because there is a one-to-one correlation between FIB entries and routing table entries, the FIB contains all known routes and eliminates the need for the route cache maintenance that is associated with switching paths such as those used in fast switching and optimum switching.

Cisco Express Forwarding FIB and Load Balancing

Several paths can lead to a destination prefix. This occurs, for example, when a router is configured for simultaneous load balancing and redundancy. For each resolved path, the FIB contains a pointer for the adjacency corresponding to the next hop interface for that path.

Cisco Express Forwarding Adjacency Tables Overview

A node is said to be adjacent to another node if the node can be reached with a single hop across a link layer (Layer 2). Cisco Express Forwarding stores forwarding information (outbound interface and MAC header rewrite) for adjacent nodes in a data structure called the adjacency table. Cisco Express Forwarding uses adjacency tables to prepend Layer 2 addressing information to packets. The adjacency tables maintain Layer 2 next-hop addresses for all FIB entries.

The following sections provide additional information about adjacencies:

- Adjacency Discovery, page 5
- Adjacency Types That Require Special Handling, page 5
- Unresolved Adjacency, page 6

Adjacency Discovery

Each adjacency table is populated as adjacencies are discovered. Adjacencies are added to the table either through indirect manual configuration or dynamically—discovered through a mechanism like Address Resolution Protocol (ARP) or added through the use of a routing protocol, such as Border Gateway Protocol (BGP) or Open Shortest Path First (OSPF), which forms neighbor relationships. Each time an adjacency entry is created, a link-layer header for that adjacent node is computed and stored in the adjacency table.

The adjacency information is subsequently used for encapsulation during Cisco Express Forwarding switching of packets.

Adjacency Types That Require Special Handling

In addition to adjacencies associated with next hop interfaces (host-route adjacencies), other types of adjacencies are used to expedite switching when certain exception conditions exist. Prefixes requiring exception processing or special handling are cached with one of the special adjacencies listed in Table 1.

Table 1 Adjacency Types That Require Special Handling

Packets of This Adjacency Type	Receive This Processing
Null adjacency	Packets destined for a Null0 interface are dropped. Null adjacency can be used as an effective form of access filtering.
Glean adjacency	When a router is connected to a multiaccess medium, the FIB table on the router maintains a prefix for the subnet rather than for the individual host prefixes. The subnet prefix points to a glean adjacency. A glean adjacency entry indicates that a particular next hop should be directly connected, but there is no MAC header rewrite information available. When the router needs to forward packets to a specific host on a subnet, Cisco Express Forwarding requests an ARP entry for the specific prefix, ARP sends the MAC address, and the adjacency entry for the host is built.
Punt adjacency	The router forwards packets that require special handling or packets sent by features that are not yet supported in conjunction with Cisco Express Forwarding switching paths to the next higher switching level for handling.
Discard adjacency	The router discards the packets.
Drop adjacency	The router drops the packets.

Unresolved Adjacency

When a link-layer header is prepended to a packet, the FIB requires the prepended header to point to an adjacency corresponding to the next hop. If an adjacency was created by the FIB and not discovered through a mechanism such as ARP, the Layer 2 addressing information is not known and the adjacency is considered incomplete or unresolved. Once the Layer 2 information is known, the packet is forwarded to the RP, and the adjacency is determined through ARP. Thus, the adjacency is resolved.

Cisco Express Forwarding Operation Modes: Central and Distributed

Cisco Express Forwarding can be enabled in one of the two modes described in the following sections:

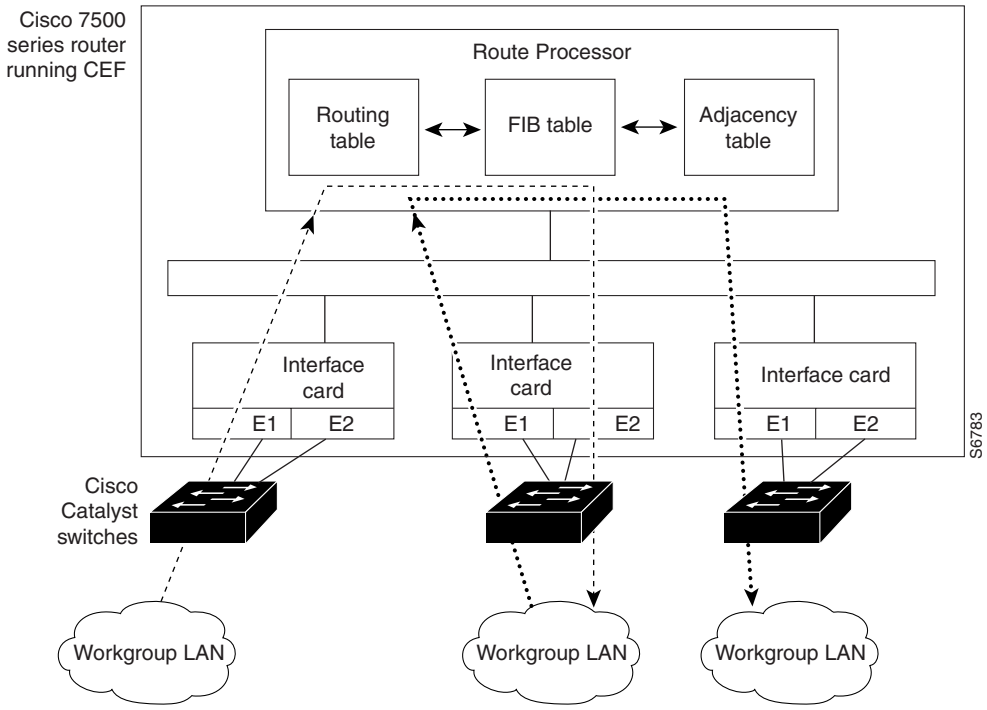
- Central Cisco Express Forwarding Mode Operation, page 6
- Distributed Cisco Express Forwarding Mode Operation, page 7

Central Cisco Express Forwarding Mode Operation

You can use central Cisco Express Forwarding mode when line cards are not available for Cisco Express Forwarding switching, when you need to use features not compatible with distributed Cisco Express Forwarding switching, or when you are running on a nondistributed platform. When central Cisco Express Forwarding mode is enabled, the Cisco Express Forwarding FIB and adjacency tables reside on the RP, and the RP performs the express forwarding.

Figure 2 shows the relationship between the routing table, the FIB, and the adjacency table during central Cisco Express Forwarding mode operation. The Catalyst switches forward traffic from workgroup LANs to a Cisco 7500 series router on the enterprise backbone running central Cisco Express Forwarding. The RP performs the express forwarding.

Figure 2 Central Cisco Express Forwarding Mode Operation



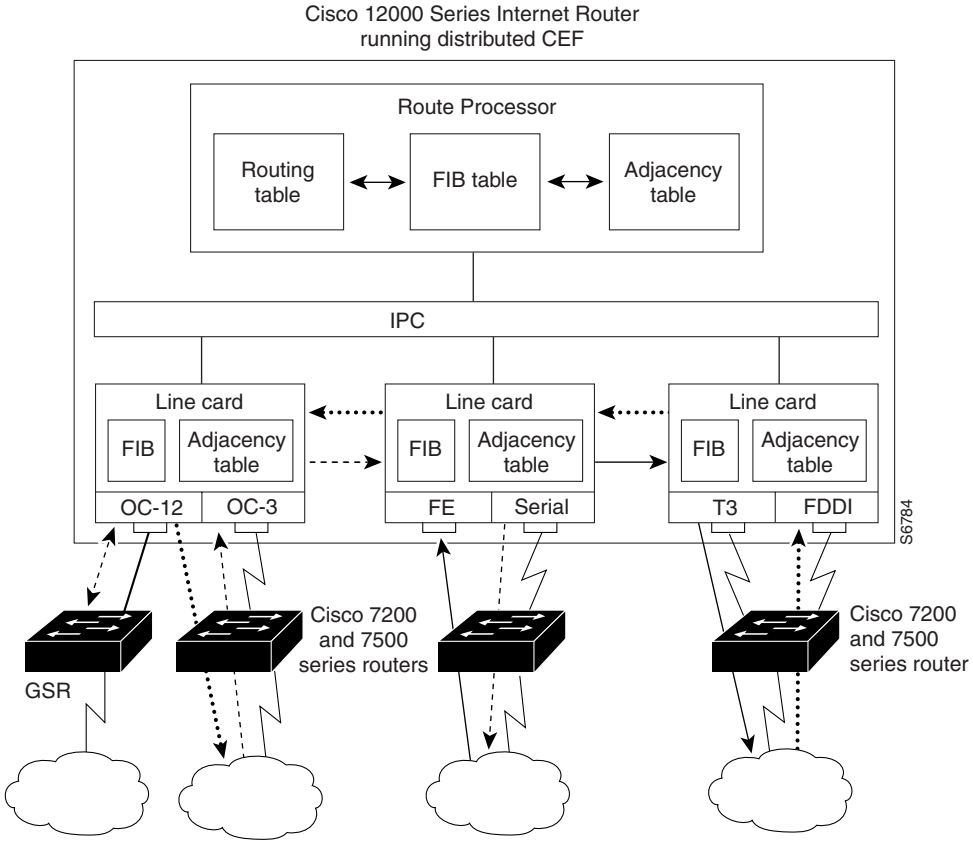
Distributed Cisco Express Forwarding Mode Operation

For additional scalability, Cisco Express Forwarding runs in the distributed Cisco Express Forwarding form on certain platforms by spreading processing tasks across two or more line cards. When distributed Cisco Express Forwarding mode is enabled, line cards maintain identical copies of the FIB and adjacency tables. The line cards perform the express forwarding between port adapters, relieving the RP of involvement in the switching operation, thus also enhancing system performance.

Distributed Cisco Express Forwarding uses an interprocess communication (IPC) mechanism to ensure synchronization of FIB tables and adjacency tables on the RP and line cards.

Figure 3 shows the relationship between the RP and line cards when distributed Cisco Express Forwarding mode is active.

Figure 3 Distributed Cisco Express Forwarding Mode Operation



In the Cisco 12000 Series Internet Router, shown in Figure 3, the line cards perform the switching. In other routers where you can mix various types of cards in the same router, all cards might not support distributed Cisco Express Forwarding. When a line card that does not support distributed Cisco Express Forwarding receives a packet on one of these other routers, the line card forwards the packet to the next higher switching layer (the RP). This structure allows legacy interface processors to exist in the router with newer interface processors.

Note The Cisco 12000 Series Internet routers operate only in distributed Cisco Express Forwarding mode.

Cisco Express Forwarding Features Enabled by Default

The following features are enabled by default when Cisco Express Forwarding is enabled:

- Per-destination load balancing and the universal load sharing algorithm (see the "Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic" module)
- Distributed tunnel switching (see the "Cisco Express Forwarding Distributed Tunnel Switching" section on page 9)
- Multipoint generic routing encapsulation (GRE) tunnels (see the "Cisco Express Forwarding-Switched Multipoint GRE Tunnels (Cisco IOS 12.2(8)T)" section on page 9)

Cisco Express Forwarding Distributed Tunnel Switching

Cisco Express Forwarding supports distributed tunnel switching, such as that made possible by GRE tunnels. Distributed tunnel switching is enabled automatically when you enable Cisco Express Forwarding or distributed Cisco Express Forwarding. You do not perform any additional tasks to enable distributed tunnel switching once you enable Cisco Express Forwarding or distributed Cisco Express Forwarding.

Cisco Express Forwarding-Switched Multipoint GRE Tunnels (Cisco IOS 12.2(8)T)

The Cisco Express Forwarding-Switched Multipoint GRE Tunnels feature enables Cisco Express Forwarding switching of IP traffic to and from multipoint GRE tunnels. Traffic can be forwarded to a prefix through a tunnel destination when both the prefix and the tunnel destination are specified by the application. GRE creates a virtual point-to-point link to other routers at remote points over an IP internetwork. GRE can encapsulate a wide variety of protocol type packets. By connecting multiprotocol subnetworks in a single-protocol backbone environment, IP tunneling using GRE allows network expansion across a single-protocol backbone environment.

Links for the Cisco Express Forwarding Features

Table 2 contains links to information about features that you can configure for use with Cisco Express Forwarding or distributed Cisco Express Forwarding operation.

Table 2 Features to Configure for Cisco Express Forwarding or Distributed Cisco Express Forwarding Operation

For Information on This Feature…	See the Following Document…
Configuring and verifying basic Cisco Express Forwarding operation	*Configuring Basic Cisco Express Forwarding for Improved Performance, Scalability, and Resiliency in Dynamic Networks*
Enabling or disabling Cisco Express Forwarding or distributed Cisco Express Forwarding switching and forwarding	*Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding to Customize Switching and Forwarding for Dynamic Networks*
Changing your load-balancing scheme	*Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic*
Refreshing or rebuilding adjacency or Cisco Express Forwarding tables	*Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables*
Configuring Cisco Express Forwarding consistency checkers	*Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards*
Configuring network accounting for Cisco Express Forwarding	*Configuring Cisco Express Forwarding Network Accounting*
Customizing the display of recorded Cisco Express Forwarding events	*Customizing the Display of Recorded Cisco Express Forwarding Events*

How to Configure Cisco Express Forwarding

There are no tasks for the Cisco Express Forwarding Overview module.

See the "Related Documents" section on page 10 for links to configuration information for Cisco Express Forwarding features and services.

Configuration Examples for Cisco Express Forwarding

There are no configuration examples for the Cisco Express Forwarding Overview module.

See the "Related Documents" section on page 10 for links to configuration information for Cisco Express Forwarding features and services.

Where to Go Next

See the "Related Documents" section on page 10 for links to configuration information for Cisco Express Forwarding features and services.

Additional References

The following sections provide references related to configuring Cisco Express Forwarding.

Related Documents

Related Topic	Document Title
List of the features documented in the Cisco Express Forwarding modules	Cisco Express Forwarding Features Roadmap
Tasks for verifying Cisco Express Forwarding information on your router	*Configuring Basic Cisco Express Forwarding for Improved Performance, Scalability, and Resiliency in Dynamic Networks*
Tasks for enabling or disabling Cisco Express Forwarding or distributed Cisco Express Forwarding	*Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding to Customize Switching and Forwarding for Dynamic Networks*
Tasks for configuring a load-balancing scheme for Cisco Express Forwarding	*Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic*
Tasks for configuring Cisco Express Forwarding consistency checkers	*Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards*
Tasks for configuring epochs for Cisco Express Forwarding tables	*Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables*
Tasks for configuring and verifying Cisco Express Forwarding network accounting	*Configuring Cisco Express Forwarding Network Accounting*
Tasks for customizing the display of recorded Cisco Express Forwarding events	*Customizing the Display of Recorded Cisco Express Forwarding Events*

Related Topic	Document Title
Verification steps for Cisco Express Forwarding switching	*How to Verify Cisco Express Forwarding Switching*
Troubleshooting tips for incomplete adjacencies	*Troubleshooting Incomplete Adjacencies with CEF*
Description and use of the Cisco Express Forwarding consistency checkers available for the Cisco 7500 and 12000 series routers	*Troubleshooting Prefix Inconsistencies with Cisco Express Forwarding*
Information about troubleshooting Cisco Express Forwarding routing loops and suboptimal routing	*Troubleshooting Cisco Express Forwarding Routing Loops*
Causes of common Cisco Express Forwarding-related error messages on platforms running distributed Cisco Express Forwarding switching (Cisco 7500 series routers and Cisco 12000 Series Internet routers) and how to troubleshoot them	*Troubleshooting Cisco Express Forwarding-Related Error Messages*
Explanation of and troubleshooting information for the Cisco IOS software implementation of Layer 3 load balancing across multiple parallel links when Cisco Express Forwarding is used	*Troubleshooting Load Balancing Over Parallel Links Using Cisco Express Forwarding*
Troubleshooting guide for unicast IP routing on Catalyst 6500/6000 switches with Supervisor Engine 2, Policy Feature Card 2 (PFC2), or Multilayer Switch Feature Card 2 (MSFC2)	*Troubleshoot Unicast IP Routing Involving CEF on Catalyst 6500/6000 Series Switches with a Supervisor Engine 2 and Running CatOS System Software*
QoS features that require Cisco Express Forwarding	*When Is CEF Required for Quality of Service*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
RFC 1701	*Generic Route Encapsulation (GRE)*
RFC 2784	*Generic Routing Encapsulation (GRE)*
RFC 2890	*Key and Sequence Number Extensions to GRE*

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Feature Information for Cisco Express Forwarding Overview

Table 3 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Release 12.2(1) or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the *Cisco Express Forwarding Features Roadmap*.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 3 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 3 Feature Information for Cisco Express Forwarding Overview

Feature Name	Releases	Feature Configuration Information
Cisco Express Forwarding-Switched Multipoint GRE Tunnels	12.2(8)T	This feature enables Cisco Express Forwarding switching of IP traffic to and from multipoint GRE tunnels. Prior to the introduction of this feature, only process switching was available for multipoint GRE tunnels. • "Cisco Express Forwarding-Switched Multipoint GRE Tunnels (Cisco IOS 12.2(8)T)" section on page 9
CEF Support for IP Routing between IEEE 802.1Q vLANs	Cisco IOS XE Release 2.1	This feature was introduced on Cisco ASR 1000 Series Routers.

Glossary

adjacency—A relationship formed between selected neighboring routers and end nodes for the purpose of exchanging routing information. Adjacency is based upon the use of a common media segment by the routers and nodes involved.

Cisco Express Forwarding—A Layer 3 switching technology. Cisco Express Forwarding can also refer to central Cisco Express Forwarding mode, one of two modes of Cisco Express Forwarding operation. Cisco Express Forwarding enables a Route Processor to perform express forwarding. Distributed Cisco Express Forwarding is the other mode of Cisco Express Forwarding operation.

distributed Cisco Express Forwarding—A mode of Cisco Express Forwarding operation in which line cards (such as Versatile Interface Processor (VIP) line cards) maintain identical copies of the forwarding information base (FIB) and adjacency tables. The line cards perform the express forwarding between port adapters; this relieves the Route Switch Processor of involvement in the switching operation.

FIB—forwarding information base. A component of Cisco Express Forwarding that is conceptually similar to a routing table or information base. The router uses the FIB lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The router maintains a mirror image of the forwarding information in an IP routing table.

GRE—generic routing encapsulation. A tunneling protocol developed by Cisco that enables encapsulation of a wide variety of protocol packet types inside IP tunnels, creating a virtual point-to-point link to Cisco routers at remote points over an IP internetwork. By connecting multiprotocol subnetworks in a single-protocol backbone environment, IP tunneling using GRE allows the expansion of a network across a single-protocol backbone environment.

IPC—interprocess communication. The mechanism that enables the distribution of Cisco Express Forwarding tables from the Route Switch Processor (RSP) to the line card when the router is operating in distributed Cisco Express Forwarding mode.

label disposition—The removal of Multiprotocol Label Switching (MPLS) headers at the edge of a network. In MPLS label disposition, packets arrive on a router as MPLS packets and, with the headers removed, are transmitted as IP packets.

label imposition—The action of putting a label on a packet.

LER—label edge router. A router that performs label imposition.

LFIB—label forwarding information base. The data structure used by switching functions to switch labeled packets.

LIB—label information base. A database used by a label switch router (LSR) to store labels learned from other LSRs, as well as labels assigned by the local LSR.

line card—A general term for an interface processor that can be used in various Cisco products. For example, a Versatile Interface Processor (VIP) is a line card for the Cisco 7500 series router.

LSP—label switched path. A sequence of hops (Router 0...Router n). A packet travels from R0 to Rn by means of label switching mechanisms. An LSP can be chosen dynamically, based on normal routing mechanisms, or it can be configured manually.

LSR—label switch router. A Layer 3 router that forwards a packet based on the value of a label encapsulated in the packet.

MPLS—Multiprotocol Label Switching. An emerging industry standard for the forwarding of packets along the normal routing paths (sometimes called MPLS hop-by-hop forwarding).

prefix—The network address portion of an IP address. A prefix is specified by a network and mask and is generally represented in the format network/mask. The mask indicates which bits are the network bits. For example, 1.0.0.0/16 means that the first 16 bits of the IP address are masked, making them the network bits. The remaining bits are the host bits. In this example, the network number is 10.0.

RIB—Routing Information Base. A central repository of routes that contains Layer 3 reachability information and destination IP addresses or prefixes. The RIB is also known as the routing table.

RP—Route Processor. The processor module in the Cisco 7000 series routers that contains the CPU, system software, and most of the memory components that are used in the router. It is sometimes called a supervisory processor.

RSP—Route Switch Processor. The processor module used in the Cisco 7500 series routers that integrates the functions of the Route Processor (RP) and the Switch Processor (SP).

SP—Switch Processor. The Cisco 7000-series processor module that acts as the administrator for all CxBus activities. It is sometimes called a CiscoBus controller.

VIP—Versatile Interface Processor. An interface card used in Cisco 7000 and Cisco 7500 series routers. The VIP provides multilayer switching and runs Cisco IOS.

VPN—Virtual Private Network. A router configuration that enables IP traffic to use tunneling to travel securely over a public TCP/IP network.

VRF—A Virtual Private Network (VPN) routing/forwarding instance. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table. In general, a VRF includes the routing information that defines a customer VPN site that is attached to a PE router.

Configuring Basic Cisco Express Forwarding for Improved Performance, Scalability, and Resiliency in Dynamic Networks

First Published: May 2, 2005
Last Updated: July 11, 2008

This module contains information about Cisco Express Forwarding and describes the required and optional tasks for verifying Cisco Express Forwarding and distributed Cisco Express Forwarding operation.

Cisco Express Forwarding is an advanced Layer 3 IP switching technology. It optimizes network performance and scalability for all kinds of networks: those that carry small amounts of traffic and those that carry large amounts of traffic in complex patterns, such as the Internet, and networks characterized by intensive web-based applications or interactive sessions.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Configuring Basic Cisco Express Forwarding" section on page 29.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

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Contents

Prerequisites for Configuring Cisco Express Forwarding

Cisco Express Forwarding requires a software image that includes Cisco Express Forwarding and IP routing enabled on the device.

Restrictions for Configuring Cisco Express Forwarding

Cisco Express Forwarding has the following restrictions:

- The Cisco 12000 Series Internet routers operate only in distributed Cisco Express Forwardingmode.
- If you enable Cisco Express Forwarding and then create an access list that uses the **log** keyword, the packets that match the access list are not Cisco Express Forwarding switched. They are process switched. Logging disables Cisco Express Forwarding.

Information About Configuring Basic Cisco Express Forwarding

Before using Cisco Express Forwarding or distributed Cisco Express Forwarding, you should understand the following:

If your network architecture requires that you disable or reenable Cisco Express Forwarding or distributed Cisco Express Forwarding switching and forwarding, change your load balancing scheme, refresh Cisco Express Forwarding tables, configure network accounting for Cisco Express Forwarding,

or customize the display of Cisco Express Forwarding events, go to the "Related Documents" section on page 26 for links to information on these tasks. Otherwise, you need do nothing more to configure Cisco Express Forwarding or distributed Cisco Express Forwarding operation in your network.

Note Cisco Express Forwarding is supported on interfaces on which IEEE 802.1Q encapsulation has been enabled at the subinterface level. You no longer need to disable CEF operation on interfaces that are using IEEE 802.1Q encapsulation on VLAN subinterfaces.

Cisco Platform Support for Cisco Express Forwarding and Distributed Cisco Express Forwarding

Cisco Express Forwarding is enabled by default on most Cisco platforms running Cisco IOS software Release 12.0 and later. When Cisco Express Forwarding in enabled on a router, the Route Processor (RP) performs the express forwarding.

To find out if Cisco Express Forwarding is enabled by default on your platform, enter the **show ip cef** command. If Cisco Express Forwarding is enabled, you receive output that looks like the following:

```
Router# show ip cef

Prefix              Next Hop            Interface
[...]
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
                    192.168.101.1       FastEthernet6/1
[...]
```

If Cisco Express Forwarding is not enabled on your platform, the output for the **show ip cef** command looks like this:

```
Router# show ip cef

%CEF not running
```

Distributed Cisco Express Forwarding is enabled by default on the Catalyst 6500 series switch, the Cisco 7500 series router, and the Cisco 12000 Series Internet Router. When distributed Cisco Express Forwarding is enabled on your platform, the line cards perform the express forwarding.

If Cisco Express Forwarding is not enabled on your platform, use the **ip cef** command to enable Cisco Express Forwarding or the **ip cef distributed** command to enable distributed Cisco Express Forwarding.

Cisco Express Forwarding Benefits: Improved Performance, Scalability, and Resiliency

Cisco Express Forwarding offers the following benefits:

- Improved performance—Cisco Express Forwarding is less CPU-intensive than fast switching route caching. As a result, more CPU processing power can be dedicated to Layer 3 services such as quality of service (QoS) and encryption.
- Scalability—Cisco Express Forwarding offers full switching capacity at each line card when distributed Cisco Express Forwarding mode is active. Distributed Cisco Express Forwarding is a distributed switching mechanism that scales linearly with the number of interface cards and the bandwidth installed in the router.

- Resiliency—Cisco Express Forwarding offers an unprecedented level of switching consistency and stability in large dynamic networks. In dynamic networks, fast-switched cache entries are frequently invalidated by routing changes. These changes can cause traffic to be process-switched through use of the routing table, rather than fast-switched through use of the route cache. Because the forwarding information base (FIB) lookup table contains all known routes that exist in the routing table, it eliminates the need for route cache maintenance and the steps involved with fast-switch or process-switch forwarding. Cisco Express Forwarding can switch traffic more efficiently than typical demand caching schemes.

Main Components for Cisco Express Forwarding Operation

Information conventionally stored in a route cache is stored in several data structures for Cisco Express Forwarding switching. The data structures provide optimized lookup for efficient packet forwarding. The two main components of Cisco Express Forwarding operation are the forwarding information base (FIB) and the adjacency tables.

The FIB is conceptually similar to a routing table or information base. A router uses this lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The FIB is updated as changes occur in the network and contains all routes known at the time. For more information on the FIB, see the "Cisco Express Forwarding Overview" module.

Adjacency tables maintain Layer 2 next-hop addresses for all FIB entries. For more information on adjacency tables, see the "Cisco Express Forwarding Overview" module.

This separation of the reachability information (in the Cisco Express Forwarding table) and the forwarding information (in the adjacency table), provides two main benefits:

- The adjacency table can be built separately from the Cisco Express Forwarding table, allowing both tables to build without the process switching of any packets.
- The MAC header rewrite used to forward a packet isn't stored in cache entries, so changes in a MAC header rewrite string do not require invalidation of cache entries.

Cisco Express Forward Operation Modes: Central and Distributed

Cisco Express Forwarding can be enabled in one of the two modes described in the following sections:

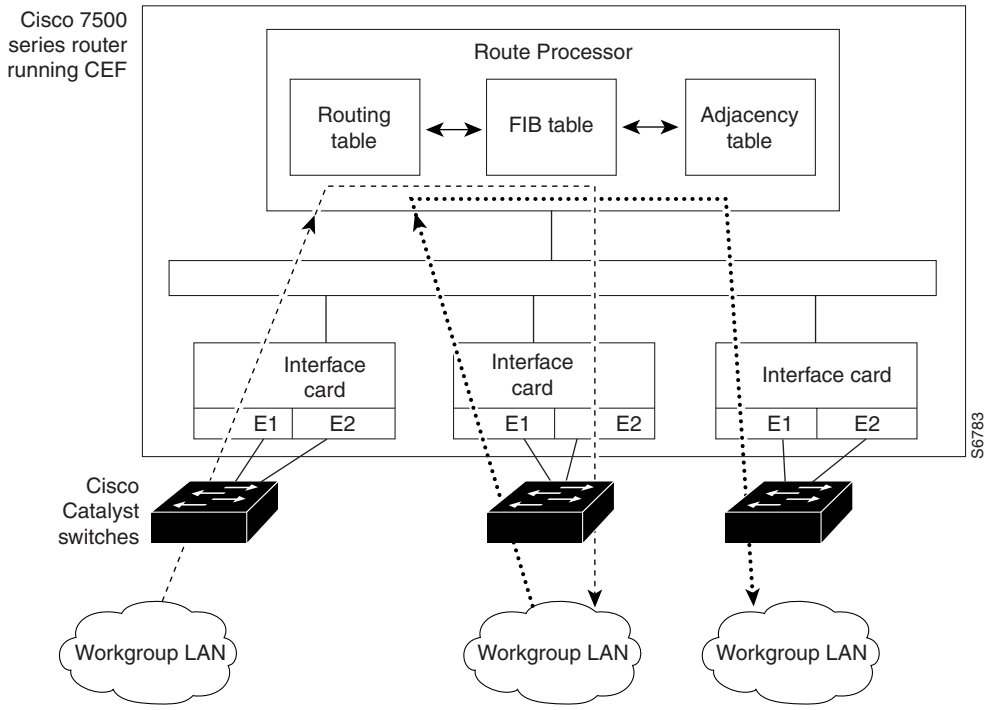
- Central Cisco Express Forwarding Mode Operation, page 4
- Distributed Cisco Express Forwarding Mode Operation, page 5

Central Cisco Express Forwarding Mode Operation

You can use central Cisco Express Forwarding mode when line cards are not available for Cisco Express Forwarding switching, when you need to use features not compatible with distributed Cisco Express Forwarding switching, or when you are running on a platform that is not a distributed platform. When central Cisco Express Forwarding mode is enabled, the Cisco Express Forwarding FIB and adjacency tables reside on the RP, and the RP performs the express forwarding.

Figure 1 shows the relationship between the routing table, the FIB, and the adjacency table during central Cisco Express Forwarding mode operation. The Catalyst switches forward traffic from workgroup LANs to a Cisco 7500 series router on the enterprise backbone running central Cisco Express Forwarding. The RP performs the express forwarding.

Figure 1 Central Cisco Express Forwarding Mode Operation



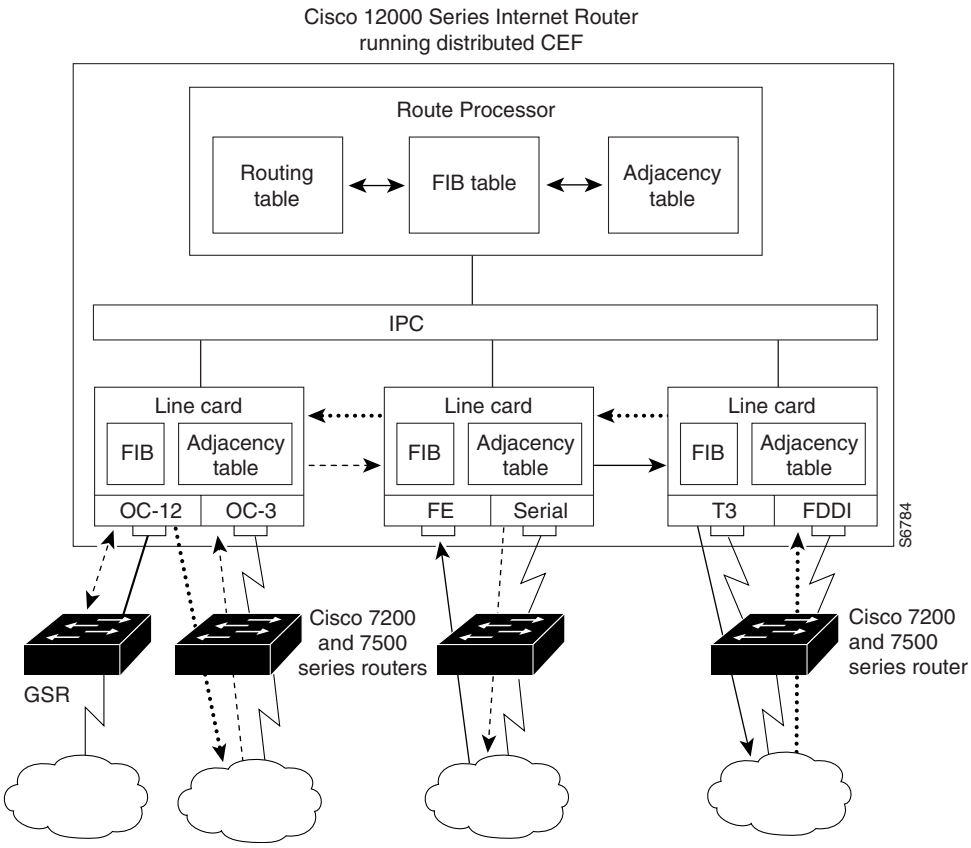
Distributed Cisco Express Forwarding Mode Operation

For additional scalability, Cisco Express Forwarding runs in the form of distributed Cisco Express Forwarding on certain platforms by spreading processing tasks across two or more line cards. When distributed Cisco Express Forwarding mode is enabled, line cards maintain identical copies of the FIB and adjacency tables. The line cards perform the express forwarding between port adapters, relieving the RP of involvement in the switching operation, thus also enhancing system performance.

Distributed Cisco Express Forwarding uses an interprocess communication (IPC) mechanism to ensure synchronization of FIB tables and adjacency tables on the RP and line cards.

Figure 2 shows the relationship between the RP and line cards when distributed Cisco Express Forwarding mode is active.

Figure 2 Distributed Cisco Express Forwarding Mode Operation



In the Cisco 12000 Series Internet Router, shown in Figure 2, the line cards perform the switching. In other routers, where you can mix various types of cards in the same router, all cards might not support distributed Cisco Express Forwarding. When a line card that does not support distributed Cisco Express Forwarding receives a packet on one of these other routers, the line card forwards the packet to the next higher switching layer (the RP). This structure allows legacy interface processors to exist in the router with newer interface processors.

Note The Cisco 12000 Series Internet routers operate only in distributed Cisco Express Forwarding mode.

How to Configure Basic Cisco Express Forwarding

There are no configuration tasks. Cisco Express Forwarding is enabled by default.

How to Verify Basic Cisco Express Forwarding

The following section contains instructions for verifying basic Cisco Express Forwarding or distributed Cisco Express Forwarding operation.

Before you perform the remaining tasks in this section you need to know which mode of Cisco Express Forwarding is running on your router. Cisco Express Forwarding is enabled by default on the Cisco 7100, 7200, and 7500 series routers. Distributed Cisco Express Forwarding is enabled by default on the Catalyst 6500 switch and on Cisco 12000 Series Internet routers. To determine if Cisco Express Forwarding or distributed Cisco Express Forwarding is enabled on your router, you can enter the **show ip interface** command and look for the entry "IP CEF switching enabled" or "IP Distributed CEF switching enabled." If Cisco Express Forwarding is not enabled, the entry in the command display would indicate that "IP CEF switching is disabled."

To verify basic Cisco Express Forwarding or distributed Cisco Express Forwarding operation, perform the following procedures and tasks:

- Determining If the Router Is Configured for Central or Distributed Cisco Express Forwarding, page 7 (required)
- Verifying Cisco Express Forwarding Operation on Your Router, page 8 (optional)
- Verifying Distributed Cisco Express Forwarding Operation on Your Router, page 15 (optional)
- Interpreting Information in Cisco Express Forwarding Command Output, page 21 (optional)

Determining If the Router Is Configured for Central or Distributed Cisco Express Forwarding

To determine if the router is configured for Cisco Express Forwarding or distributed Cisco Express Forwarding, perform the following task.

SUMMARY STEPS

1. **enable**
2. **show ip interface** [*type number*] [**brief**]
3. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show ip interface** [*type number*] [**brief**] **Example:** `Router# show ip interface`	Displays the usability status of interfaces configured for IP. • The *type* argument is the interface type. • The *number* argument is the interface number. • The **brief** keyword displays a summary of the usability status information. Look for the entry "IP CEF switching enabled" or "IP Distributed CEF switching enabled."
Step 3	**exit** **Example:** `Router# exit`	Exits to user EXEC mode.

What to Do Next

- If the router is configured for Cisco Express Forwarding, complete the steps in each of the tasks on the RP in the "Verifying Cisco Express Forwarding Operation on Your Router" section on page 8.
- If the router is configured for distributed Cisco Express Forwarding, complete the steps in each of the tasks on the line card in the "Verifying Distributed Cisco Express Forwarding Operation on Your Router" section on page 15. You might also need to complete steps, as indicated in each task, on the RP. By performing the same steps on the RP that you do on the line cards, you can verify that the forwarding tables on the RP and the line cards are synchronized.

Verifying Cisco Express Forwarding Operation on Your Router

Perform the following tasks, in the order presented, to verify Cisco Express Forwarding operation on your router or to look for Cisco Express Forwarding operation information on your router:

See the "Verifying Distributed Cisco Express Forwarding Operation on Your Router" section on page 15 for the tasks to perform for d istributed Cisco Express Forwarding operation.

Verifying That Cisco Express Forwarding Switching Is Enabled on the Input Interface on the Router

To verify tha Cisco Express Forwarding switching is enabled on the input (ingress) interface on the router, perform the following steps.

SUMMARY STEPS

1. **enable**
2. **show ip cef**
3. **show cef interface** *type number* **detail**
4. **show ip interface** *type number*
5. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. You can also enter this command in user EXEC mode. Enter your password if prompted. For example:

```
Router> enable
Router#
```

Step 2 **show ip cef**

Use this command to verify that Cisco Express Forwarding is enabled globally. For example:

```
Router# show ip cef

%CEF not running
```

If Cisco Express Forwarding is not running, use the **ip cef** command to enable Cisco Express Forwarding or the **ip cef distributed** command to enable distributed Cisco Express Forwarding.

When Cisco Express Forwarding or distributed Cisco Express Forwarding is enabled, the **show ip cef** command shows a brief display of all FIB entries.

Step 3 **show cef interface** *type number* **detail**

Use this command to verify that Cisco Express Forwarding is enabled on a particular ingress interface. Look for the entry "IP CEF switching enabled." For example:

```
Router# show cef interface fastethernet 1/0/0 detail

FastEthernet1/0/0 is up (if_number 9)
  Corresponding hwidb fast_if_number 9
  Corresponding hwidb firstsw->if_number 9
  Internet address is 10.2.61.8/24
  ICMP redirects are always sent
  Per packet load-sharing is disabled
  IP unicast RPF check is disabled
  Inbound access list is not set
  Outbound access list is not set
  IP policy routing is disabled
  Hardware idb is FastEthernet1/0/0
  Fast switching type 1, interface type 5
  IP CEF switching enabled
  IP Feature Fast switching turbo vector
  IP Feature CEF switching turbo vector
```

```
  Input fast flags 0x0, Output fast flags 0x0
  ifindex 7(7)
  Slot 1 Slot unit 0 VC -1
  Transmit limit accumulator 0x48001A82 (0x48001A82)
  IP MTU 1500
```

Step 4 **show ip interface** *type number*

Use this command to display the Cisco IOS switching methods enabled on an interface. For example:

```
router# show ip interface fastethernet 1/0/0

 FastEthernet1/0/0 is up, line protocol is up

   IP fast switching is enabled
   IP fast switching on the same interface is enabled
   IP Flow switching is disabled
   IP CEF switching is enabled
   IP Distributed switching is enabled
   IP Fast switching turbo vector
   IP Normal CEF switching turbo vector
   IP multicast fast switching is enabled
   IP multicast distributed fast switching is disabled
   IP route-cache flags are Fast, Distributed, No CEF
```

In the above output, the “IP CEF switching is enabled” entry indicates that Cisco Express Forwarding is enabled by default. The “No CEF” IP route-cache flag indicates that Cisco Express Forwarding is disabled because an administrator entered the **no ip route-cache cef** command on this interface.

To enable Cisco Express Forwarding on this interface, enter the **ip route-cache cef** command. Once you do that, the “CEF” flag indicates that Cisco Express Forwarding is running.

Step 5 **exit**

Use this command to exit privileged EXEC mode. For example:

```
Router# exit
Router>
```

Locating the Prefix in a Forwarding Table on the RP

To locate the prefix in a forwarding table, perform the following steps.

SUMMARY STEPS

1. **enable**
2. **show ip cef**
3. **show ip cef vrf** *vrf-name*
4. Repeat Step 2 as many times as required to locate the prefix.
5. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. You can also enter this command in user EXEC mode. Enter your password if prompted. For example:

```
Router> enable
Router#
```

Step 2 **show ip cef**

Use this command to show entries in the FIB and confirm that prefixes are listed in the FIB. For example:

```
Router# show ip cef

Prefix              Next Hop            Interface
[...]
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
                    192.168.101.1       FastEthernet6/1
[...]
```

Step 3 **show ip cef vrf** *vrf-name*

Use this command to locate prefixes in forwarding tables associated with Virtual Private Network (VPN) routing/forwarding table instances (VRFs). For example, this command shows prefixes in the left-hand column for a VRF named vpn1:

```
Router# show ip cef vrf vpn1

Prefix              Next Hop            Interface
0.0.0.0/32          receive
10.1.0.0/8          10.0.0.1            Ethernet1/3
10.2.0.0/8          10.0.0.2            POS6/0
10.0.0.0/8          attached            Ethernet1/3
10.0.0.0/32         receive
10.0.0.1/32         10.0.0.1            Ethernet1/3
10.0.0.2/32         receive
10.255.255.255/32   receive
10.3.0.0/8          10.0.0.2            POS6/0
10.50.0.0/24        receive
255.255.255.255/32  receive
```

Step 4 Repeat Step 2 as many times as required to locate the prefix.

If Cisco Express Forwarding is in a VPN, you might need to look at multiple VRFs.

Step 5 **exit**

Use this command to exit privileged EXEC mode. For example:

```
Router# exit
Router>
```

Finding the Cisco Express Forwarding Output Information Associated with the Prefix on the RP

To find the Cisco Express Forwarding output information associated with the prefix on the RP, perform the following steps.

SUMMARY STEPS

1. **enable**
2. **show ip cef**
3. **show ip cef** *prefix*
4. **show ip cef** *prefix* **detail**
5. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. You can also enter this command in user EXEC mode. Enter your password if prompted. For example:

```
Router> enable
Router#
```

Step 2 **show ip cef**

Use this command to confirm that the prefix is listed in the FIB. For example:

```
router# show ip cef

Prefix              Next Hop            Interface
0.0.0.0/32          receive
192.168.0.0/30      attached            Serial2/0/0:1
192.168.0.0/32      receive
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
```

Step 3 **show ip cef** *prefix*

Use this command to display the prefix entry in the FIB for centralized Cisco Express Forwarding. For example:

```
Router# show ip cef 10.2.61.8 255.255.255.0

10.0.0.0/8, version 72, per-destination sharing
0 packets, 0 bytes
  via 192.168.100.1, 0 dependencies, recursive
    traffic share 1
    next hop 192.168.100.1, FastEthernet1/0/0 via 192.168.100.1/32
    valid adjacency
  via 192.168.101.1, 0 dependencies, recursive
    traffic share 1
    next hop 192.168.101.1, FastEthernet6/1 via 192.168.101.1/32
    valid adjacency
  0 packets, 0 bytes switched through the prefix
```

Step 4 **show ip cef** *prefix* **detail**

Use this command to show more detail for each of the active paths associated with a destination prefix. For example:

```
Router# show ip cef 10.0.0.0 detail
```

```
10.0.0.0/8, version 72, per-destination sharing
0 packets, 0 bytes
  via 192.168.100.1, 0 dependencies, recursive
    traffic share 1
    next hop 192.168.100.1, FastEthernet1/0/0 via 192.168.100.1/32
    valid adjacency
  via 192.168.101.1, 0 dependencies, recursive
    traffic share 1
    next hop 192.168.101.1, FastEthernet6/1 via 192.168.101.1/32
    valid adjacency
  0 packets, 0 bytes switched through the prefix
```

Step 5 **exit**

Use this command to exit privileged EXEC mode. For example:

```
Router# exit
Router>
```

Verifying the Adjacency or Next-Hop Information on the RP

To verify the adjacency or next-hop information, perform the following steps.

Adjacencies are added to the adjacency table when the adjacency is

- Indirectly configured manually
- Dynamically discovered through ARP
- Created when a routing protocol, for example, Border Gateway Protocol (BGP) or Open Shortest Path First (OSPF), forms a neighbor relationship

For more information on adjacencies, see the "Cisco Express Forwarding Overview" module.

SUMMARY STEPS

1. **enable**
2. **show ip cef**
3. **show adjacency detail**
4. **show adjacency summary**
5. **show adjacency** *type number*
6. **show ip cef exact-route** *source-address destination-address*
7. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. You can also enter this command in user EXEC mode. Enter your password if prompted. For example:

```
Router> enable
Router#
```

Step 2 **show ip cef**

Use this command to find the output interface. For example:

```
router# show ip cef

Prefix              Next Hop            Interface
0.0.0.0/32          receive
192.168.0.0/30      attached            Serial2/0/0:1
192.168.0.0/32      receive
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
```

In this example, the output interface for the prefix 10.2.61.8/24 is FastEthernet 1/0/0, and the next hop address is 192.168.100.1.

Step 3 **show adjacency detail**

Use this command to display adjacency information, including Layer 2 information. For example:

```
Router# show adjacency detail

Protocol Interface                Address
IP       Ethernet1/0/0            10.2.61.8(7)
                                  0 packets, 0 bytes
                                  00107BC30D5C
                                  00500B32D8200800
                                  ARP        02:01:49
```

The encapsulation string 00107BC30D5C00500B32D8200800 is that of an adjacency used for traffic switched out of a router on an Ethernet link by means of Ethernet II encapsulation.

Step 4 **show adjacency summary**

Use this command to display Cisco Express Forwarding adjacency table summary information. For example:

```
Router# show adjacency summary

Adjacency Table has 1 adjacency
  Interface                Adjacency Count
  Ethernet1/0/0            1
```

Step 5 **show adjacency** *type number*

Use this command to display adjacency information for a particular interface. For example:

```
Router# show adjacency fastethernet 2/3

Protocol  Interface                 Address
IP        FastEthernet2/3           172.20.52.1(3045)
IP        FastEthernet2/3           172.20.52.22(11)
```

Step 6 **show ip cef exact-route** *source-address destination-address*

Use this command to display the exact route for a source-destination IP address pair and verify the next-hop address. For example:

```
Router# show ip cef exact-route 10.1.1.1 10.2.61.8

10.1.1.1         -> 10.2.61.8 :FastEthernet1/0/0 (next hop 192.168.100.1)
```

In this example, the exact route from source address 10.1.1.1 to destination address 10.2.61.8 is through interface Ethernet1/0/0 to next hop address 192.168.100.1.

Step 7 **exit**

Use this command to exit privileged EXEC mode. For example:

```
Router# exit
Router>
```

Verifying Distributed Cisco Express Forwarding Operation on Your Router

Perform the following tasks, in the order presented, to verify distributed Cisco Express Forwarding operation on your router:

- Verifying That Distributed Cisco Express Forwarding Switching Is Enabled on the Input Interface on a Line Card, page 15
- Locating the Prefix in a Forwarding Table on a Line Card, page 16
- Finding the Distributed Cisco Express Forwarding Output Information Associated with the Prefix on a Line Card, page 18
- Verifying the Adjacency or Next-Hop Information on a Line Card, page 19

Syntax for Cisco Express Forwarding Commands on Line Cards

To perform tasks on router line cards, you need to use the following syntax: **execute-on** [**slot** *slot-number* | **all**] *command*. The **execute-on** commands apply only to the Cisco 12000 Series Internet routers and the Cisco 7500 series routers. The **all** keyword is available only on the Cisco 12000 Series Internet routers.

For example, use the following command to display FIB entries on the line cards in the first slot:

```
Router# execute-on 0 show ip cef
```

To perform tasks on a Catalyst 6500 series switch, you use the following syntax: **remote command module** *mod command*. For example:

```
Router# remote command module 2 show ip cef
```

The tasks in this document apply to the Cisco 7500 series and Cisco 12000 Series Internet routers.

Verifying That Distributed Cisco Express Forwarding Switching Is Enabled on the Input Interface on a Line Card

To verify that distributed Cisco Express Forwarding switching is enabled on the input (ingress) interface on the line card, perform the following steps.

SUMMARY STEPS

1. **enable**
2. **show ip cef**
3. **execute-on slot** *slot-number* **show ip cef** *prefix*
4. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. You can also enter this command in user EXEC mode. Enter your password if prompted. For example:

```
Router> enable
Router#
```

Step 2 **show ip cef**

Use this command to verify that Cisco Express Forwarding is enabled globally. For example:

```
Router# show ip cef

%CEF not running
```

If Cisco Express Forwarding is not running, use the **ip cef** command to enable (central) Cisco Express Forwarding or the **ip cef distributed** command to enable distributed Cisco Express Forwarding.

When Cisco Express Forwarding or distributed Cisco Express Forwarding is enabled, the **show ip cef** command shows a brief display of all FIB entries.

Step 3 **execute-on slot** *slot-number* **show ip cef** *prefix*

Use this command to verify information about interfaces on a line card. For example:

```
Router# execute-on slot 0 show ip cef 192.68.0.0 255.255.255.0

show ip cef 192.68.0.0 255.255.255.0 from slot 0:

192.68.0.0/24, version 19, epoch 0, attached, connected
0 packets, 0 bytes
  via Ethernet5/0/0, 0 dependencies
    valid glean adjacency
```

Step 4 **exit**

Use this command to exit privileged EXEC mode. For example:

```
Router# exit
Router>
```

Locating the Prefix in a Forwarding Table on a Line Card

To locate the prefix in a forwarding table on the line card, perform the following steps.

SUMMARY STEPS

1. **enable**
2. **execute-on slot** *slot-number* **show ip cef**
3. **execute-on all show ip cef *vrf*** *vrf-name*
4. Repeat Step 2 as many times as required to locate the prefix.
5. **show ip cef**
6. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. You can also enter this command in user EXEC mode. Enter your password if prompted. For example:

```
Router> enable
Router#
```

Step 2 **execute-on slot** *slot-number* **show ip cef**

Use this command to show entries in the FIB on the line card and confirm that prefixes are listed in the FIB. For example:

```
Router# execute-on slot 0 show ip cef

show ip cef from slot 0:

Prefix              Next Hop            Interface
0.0.0.0/0           192.168.0.1          Ethernet5/0/0
0.0.0.0/32          receive
192.168.0.0/24      attached             Ethernet5/0/0
192.168.0.0/32      receive
192.168.0.1/32      192.168.0.1          Ethernet5/0/0
192.168.0.141/32    receive
192.168.0.255/32    receive
239.224.0.0/4       drop
239.224.0.0/24      receive
255.255.255.255/32  receive
```

Step 3 **execute-on all show ip cef vrf** *vrf-name*

Use this command to locate prefixes in forwarding tables associated with Virtual Private Network (VPN) routing/forwarding instances (VRFs). For example, this command shows prefixes in the left-hand column for a VRF named vpn1:

```
Router# execute-on all show ip cef vrf vpn1

Prefix              Next Hop            Interface
0.0.0.0/32          receive
10.1.0.0/8          10.0.0.1            Ethernet1/3
10.2.0.0/8          10.0.0.2            POS6/0
10.0.0.0/8          attached            Ethernet1/3
10.0.0.0/32         receive
10.0.0.1/32         10.0.0.1            Ethernet1/3
10.0.0.2/32         receive
10.255.255.255/32   receive
10.3.0.0/8          10.0.0.2            POS6/0
10.50.0.0/24        receive
255.255.255.255/32  receive
```

Step 4 Repeat Step 2 as many times as required to locate the prefix.

If distributed Cisco Express Forwarding is in a VPN, you might need to look at multiple VRFs.

Step 5 **show ip cef**

Use this command to show entries in the FIB on the RP and to verify that the FIB on the line card is synchronized with the FIB maintained by the router. For example:

```
Router# show ip cef

Prefix              Next Hop            Interface
[...]
```

```
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
                    192.168.101.1       FastEthernet6/1
[...]
```

Compare the prefixes, next hops, and interfaces in this output with those in the output from Step 1 to verify that FIB on the line card is synchronized with the FIB maintained by the router.

Step 6 **exit**

Use this command to exit privileged EXEC mode. For example:

```
Router# exit
Router>
```

Finding the Distributed Cisco Express Forwarding Output Information Associated with the Prefix on a Line Card

To find the distributed Cisco Express Forwarding output information associated with the prefix on a line card, perform the following steps.

SUMMARY STEPS

1. **enable**
2. **execute-on slot** *slot-number* **show ip cef**
3. **execute-on slot** *slot-number* **show ip cef** *prefix*
4. **execute-on slot** *slot-number* **show ip cef** *prefix* **detail**
5. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. You can also enter this command in user EXEC mode. Enter your password if prompted. For example:

```
Router> enable
Router#
```

Step 2 **execute-on slot** *slot-number* **show ip cef**

Use this command to confirm that the prefix is listed in the FIB. For example:

```
Router# execute-on slot 0 show ip cef

show ip cef from slot 0:

Prefix              Next Hop            Interface
0.0.0.0/0           192.168.0.1          Ethernet5/0/0
0.0.0.0/32          receive
192.168.0.0/24      attached             Ethernet5/0/0
192.168.0.0/32      receive
192.168.0.1/32      192.168.0.1          Ethernet5/0/0
192.168.0.141/32    receive
192.168.0.255/32    receive
239.224.0.0/4       drop
239.224.0.0/24      receive
255.255.255.255/32  receive
```

Step 3 **execute-on slot** *slot-number* **show ip cef** *prefix*

Use this command to display the prefix entry in the FIB on a line card. For example:

```
Router# execute-on slot 3 show ip cef 192.68.0.0 255.255.255.0

show ip cef 192.168.0.0 255.255.255.0 from slot 0:

192.168.0.0/24, version 19, epoch 0, attached, connected
0 packets, 0 bytes
  via Ethernet5/0/0, 0 dependencies
    valid glean adjacency
```

Step 4 **execute-on slot** *slot-number* **show ip cef** *prefix* **detail**

Use this command to show more detail for each of the active paths associated with a destination prefix on a line card. For example:

```
Router# execute-on slot 0 show ip cef 10.24.48.32 detail

show ip cef 192.168.0.0 255.255.255.0 from slot 0:

192.168.0.0/24, version 19, epoch 0, attached, connected
0 packets, 0 bytes
  via Ethernet5/0/0, 0 dependencies
    valid glean adjacency
```

Step 5 **exit**

Use this command to exit privileged EXEC mode. For example:

```
Router# exit
Router>
```

Verifying the Adjacency or Next-Hop Information on a Line Card

To verify the adjacency or next-hop information on a line card, perform the following steps.

Cisco Express Forwarding adds an adjacency to the adjacency table when the adjacency is

- Indirectly configured manually
- Dynamically discovered through ARP
- Created when a routing protocol, for example, BGP or OSPF, forms a neighbor relationship

For more information on adjacencies, see the "Cisco Express Forwarding Overview" module.

SUMMARY STEPS

1. **enable**
2. **show ip cef**
3. **show adjacency detail**
4. **show adjacency summary**
5. **show adjacency** *type number*
6. **show ip cef exact-route** *source-address destination-address*

7. **execute-on all show ip cef** *destination*
8. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. You can also enter this command in user EXEC mode. Enter your password if prompted. For example:

```
Router> enable
Router#
```

Step 2 **show ip cef**

Use this command to determine the output interface. For example:

```
router# show ip cef

Prefix              Next Hop            Interface
0.0.0.0/32          receive
192.168.0.0/30      attached            Serial2/0/0:1
192.168.0.0/32      receive
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
```

In this example, the output interface for the prefix 10.2.61.8/24 is FastEthernet 1/0/0, and the next hop address is 192.168.100.1.

Step 3 **show adjacency detail**

Use this command to display adjacency information, including Layer 2 information. For example:

```
Router# show adjacency detail

Protocol Interface                 Address
IP       Ethernet1/0/0             10.2.61.8(7)
                                   0 packets, 0 bytes
                                   00107BC30D5C
                                   00500B32D8200800
                                   ARP        02:01:49
```

The encapsulation string 00107BC30D5C00500B32D8200800 is that of an adjacency used for traffic switched out of a router on an Ethernet link by means of Ethernet II encapsulation. (The first 12 characters are the MAC address of the destination next-hop interface. The next 12 characters represent the MAC address of the source interface of the packet. The last 4 characters [0x0800] represent the Ethernet II encapsulation value for IP.)

Step 4 **show adjacency summary**

Use this command to display Cisco Express Forwarding adjacency table summary information. For example:

```
Router# show adjacency summary

Adjacency Table has 1 adjacency
  Interface                Adjacency Count
  Ethernet1/0/0            1
```

Step 5 **show adjacency** *type number*

Use this command to display adjacency information for a particular interface. For example:

```
Router# show adjacency fastethernet 2/3
```

```
Protocol  Interface                 Address
IP        FastEthernet2/3           172.20.52.1(3045)
IP        FastEthernet2/3           172.20.52.22(11)
```

Step 6 **show ip cef exact-route** *source-address destination-address*

Use this command to display the exact route for a source-destination IP address pair and verify the next-hop address. For example:

```
Router# show ip cef exact-route 10.1.1.1 10.2.61.8

10.1.1.1         -> 10.2.61.8 :FastEthernet1/0/0 (next hop 192.168.100.1)
```

In this example, the exact route from source address 10.1.1.1 to destination address 10.2.61.8 is through interface Ethernet1/0/0 to next hop address 192.168.100.1.

Step 7 **execute-on all show ip cef** *destination*

Use this command to display output interfaces and next hops for all line cards. For example:

```
Router# execute-on all show ip cef 10.20.84.32

========= Line Card (Slot 1) =======
10.16.0.0/13, version 408935, cached adjacency 0.0.0.0
0 packets, 0 bytes
Flow: AS 6172, mask 13
via 172.16.213.1, 0 dependencies, recursive
next hop 172.16.213.1, POS1/0.500 via 172.16.213.0/30
valid cached adjacency

========= Line Card (Slot 2) =======
10.16.0.0/13, version 13719, cached adjacency 0.0.0.0
0 packets, 0 bytes
Flow: AS 6172, mask 13
via 172.16.213.1, 0 dependencies, recursive
next hop 172.16.213.1, POS1/0.500 via 172.16.213.0/30
valid cached adjacency
```

Step 8 **exit**

Use this command to exit privileged EXEC mode. For example:

```
Router# exit
Router>
```

Interpreting Information in Cisco Express Forwarding Command Output

Perform the following tasks to interpret information in Cisco Express Forwarding command output:

- Verifying That the Cisco Express Forwarding Information Looks As Expected, page 22 (optional)
- Interpreting MPLS Information in Cisco Express Forwarding Output, page 24 (optional)

Verifying That the Cisco Express Forwarding Information Looks As Expected

Perform the following tasks to verify that the Cisco Express Forwarding information looks as you expected.

SUMMARY STEPS

1. **enable**
2. **show ip route**
3. **show ip cef**
4. Compare the command output in Steps 1 and 2.
5. **execute-on slot** *slot-number* **show ip cef**
6. Compare the command output in Steps 2 and 4.
7. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. You can also enter this command in user EXEC mode. Enter your password if prompted. For example:

```
Router> enable
Router#
```

Step 2 **show ip route**

Use this command to look at the forwarding information contained in the IP routing table. For example:

```
Router# show ip route
...

     10.1.0.0/32 is subnetted, 1 subnets
O       10.1.2.3 [110/3] via 10.5.5.5, 00:00:03, POS2/0/0
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.5.5.5/32 is directly connected, POS2/0/0
C       10.5.5.0/24 is directly connected, POS2/0/0
     10.7.0.0/24 is subnetted, 1 subnets
O       10.7.8.0 [110/3] via 10.5.5.5, 00:00:04, POS2/0/0
     10.0.0.0/24 is subnetted, 2 subnets
O       10.23.64.0 [110/12] via 10.5.5.5, 00:00:04, POS2/0/0
O       10.23.66.0 [110/12] via 10.5.5.5, 00:00:04, POS2/0/0
     10.47.0.0/32 is subnetted, 1 subnets
O       10.47.0.10 [110/3] via 10.5.5.5, 00:00:04, POS2/0/0
O    172.16.57.0/24 [110/3] via 10.5.5.5, 00:00:04, POS2/0/0
     10.150.0.0/24 is subnetted, 1 subnets
C       10.150.3.0 is directly connected, Fddi0/0/0
O    192.168.92.0/24 [110/2] via 10.5.5.5, 00:00:04, POS2/0/0
```

In the example, c indicates a directly connected route and o represents a route discovered by means of OSPF.

Step 3 **show ip cef**

Use this command to display entries in the FIB. For example:

```
Router# show ip cef

Prefix              Next Hop            Interface
0.0.0.0/0           10.5.5.5             POS2/0/0(default route)
0.0.0.0/32          receive
10.1.2.3/32         10.5.5.5             POS2/0/0(two paths)
                    10.150.3.9           Fddi0/0/0
10.5.5.0/24         attached             POS2/0/0
10.5.5.0/32         receive
10.5.5.5/32         attached             POS2/0/0(glean adjacency)
10.5.5.6/32         receive(our interface)
10.5.5.255/32       receive(broadcast)
10.7.8.0/24         10.5.5.5             POS2/0/0
                    10.150.3.9           Fddi0/0/0
10.23.64.0/24       10.150.3.9           Fddi0/0/0
10.23.66.0/24       10.150.3.9           Fddi0/0/0(normal route)
10.47.0.10/32       10.150.3.9           Fddi0/0/0
10.150.3.0/24       attached             Fddi0/0/0
10.150.3.0/32       receive
10.150.3.1/32       receive
10.150.3.255/32     receive
192.168.92.0/24     10.5.5.5             POS2/0/0
                    10.150.3.9           Fddi0/0/0
172.16.57.0/24      10.5.5.5             POS2/0/0
                    10.150.3.9           Fddi0/0/0
239.224.0.0/4       receive(multicast)
255.255.255.255/32  receive(all 1s broadcast)
```

Step 4 Compare the command output in Steps 1 and 2.

Cisco Express Forwarding maintains the information contained in the IP routing table structured in a way that optimizes forwarding. Check that there is a one-to-one correlation between FIB entries and routing table entries. For example, the following lines from the sample output in Step 1 and Step 2 show a one-to-one correlation. The destination prefix 192.92.92.0/24, the next hop IP address 10.5.5.5, and the next-hop interface POS2/0/0 are the same.

- From the **show ip route** command output in Step 1:

  ```
  O    192.168.92.0/24 [110/2] via 10.5.5.5, 00:00:04, POS2/0/0
  ```

- From the **show ip cef** command output in Step 2:

  ```
  192.168.92.0/24      10.5.5.5             POS2/0/0
  ```

If there is not a one-to-one correlation, you can recreate the central FIB table by clearing the IP routing table and allowing the routing table to be rebuilt, which in turn causes the central FIB table to be repopulated with up-to-date routing information.

Step 5 (For distributed Cisco Express Forwarding operation only) **execute-on slot** *slot-number* **show ip cef**

Use this command to display FIB entries on all line cards. For example:

```
Router# execute-on slot 2 show ip cef

show ip cef from slot 2:

Prefix              Next Hop            Interface
0.0.0.0/0           10.5.5.5             POS2/0/0
0.0.0.0/32          receive
10.1.2.3/32         10.5.5.5             POS2/0/0
                    10.150.3.9           Fddi0/0/0
```

```
105.5.5.0/24        attached            POS2/0/0
10.5.5.0/32         receive
10.5.5.5/32         attached            POS2/0/0
10.5.5.6/32         receive
10.5.5.255/32       receive
10.7.8.0/24         10.5.5.5            POS2/0/0
                    10.150.3.9          Fddi0/0/0
10.7.54.0/24        attached            Fddi0/1/0
10,7.54.0/32        receive
10.7.54.3/32        receive
10.7.54.255/32      receive
10.23.64.0/24       10.150.3.9          Fddi0/0/0
10.23.66.0/24       10.150.3.9          Fddi0/0/0
10.47.0.10/32       10.150.3.9          Fddi0/0/0
10.150.3.0/24       attached            Fddi0/0/0
10.150.3.0/32       receive
10.150.3.1/32       receive
10.150.3.255/32     receive
192.168.92.0/24     10.5.5.5            POS2/0/0
                    10.150.3.9          Fddi0/0/0
172.16.57.0/24      10.5.5.5            POS2/0/0
                    10.150.3.9          Fddi0/0/0
239.224.0.0/4       receive
255.255.255.255/32  receive
```

Step 6 (For distributed Cisco Express Forwarding operation only) Compare the command output in Steps 2 and 4.

The output from the **show ip cef** command in Step 2 should be identical to the output from the **execute-on slot 2 show ip cef** command in Step 4. If the outputs are not identical, see the "Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards" module for information on synchronizing FIB entries on the RP and the line card.

Step 7 **exit**

Use this command to exit privileged EXEC mode. For example:

```
Router# exit
Router>
```

Interpreting MPLS Information in Cisco Express Forwarding Output

Perform the following steps to interpret Multiprotocol Label Switching (MPLS) information in Cisco Express Forwarding output.

Cisco Express Forwarding and MPLS Interaction

Cisco Express Forwarding interacts with a label switched path (LSP) primarily at the beginning and end of the LSP—that is, on label imposition (IP packet to MPLS packet) and label disposition (MPLS packet to IP packet). Output from Cisco Express Forwarding commands should show these processes.

The Cisco implementation of MPLS leverages the advantages of Cisco Express Forwarding. When you use a router as an MPLS edge router, Cisco Express Forwarding identifies the route for incoming packets and finds the label to apply to the packet.

However, when you use a router as a label switch router (LSR), tables from the MPLS label forwarding information base (LFIB) are used to switch MPLS packets. These tables are distributed to the Versatile Interface Processor (VIP) or to line cards in the same way that the FIB tables are distributed in Cisco Express Forwarding.

MPLS VPNs and Cisco Express Forwarding Tables

A customer-site VRF contains all the routes available to the site from the VPNs to which it belongs. VPN routing information is stored in the IP routing table and in the Cisco Express Forwarding table for each VRF. A separate set of tables is maintained for each VRF, which prevents information from being forwarded outside a VPN and prevents packets that are outside a VPN from being forwarded to a router within the VPN. Based on the routing information stored in the VRF IP routing table and the VRF Cisco Express Forwarding table, packets are forwarded to their destinations. Output from Cisco Express Forwarding commands shows details from the VRF Cisco Express Forwarding tables.

SUMMARY STEPS

1. **enable**
2. **show ip cef vrf** *vrf-name* **detail**
3. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. You can also enter this command in user EXEC mode. Enter your password if prompted. For example:

```
Router> enable
Router#
```

Step 2 **show ip cef vrf** *vrf-name* **detail**

Use this command to display detailed information from the Cisco Express Forwarding forwarding table that is associated with a VRF. For example:

```
Router# show ip cef vrf vpn1 detail

IP CEF with switching (Table Version 10), flags=0x0
  8 routes, 0 reresolve, 0 unresolved (0 old, 0 new)
  46 leaves, 51 nodes, 54640 bytes, 361 inserts, 315 invalidations
  0 load sharing elements, 0 bytes, 0 references
  universal per-destination load sharing algorithm, id F968AD29
  5 CEF resets, 38 revisions of existing leaves
  refcounts:  1400 leaf, 1392 node

Adjacency Table has 2 adjacencies
0.0.0.0/32, version 0, receive
192.168.6.0/24, version 9, cached adjacency to Serial0/1.1
0 packets, 0 bytes
```

The following section of the Cisco Express Forwarding output provides MPLS information for the first adjacency. The “tag rewrite” is an equivalent of a Cisco Express Forwarding adjacency. Look at the tags imposed field. The first tag {20} is the tag used to reach the next hop, 10.1.1.13. The second tag {30} is the tag advertised to the local provider edge (PE) router by the remote PE router.

```
  tag information set
    local tag: VPN-route-head
    fast tag rewrite with Se0/1.1, point2point, tags imposed: {20 30}
  via 10.10.10.6, 0 dependencies, recursive
    next hop 10.1.1.13, Serial0/1.1 via 10.10.10.6
    valid cached adjacency
    tag rewrite with Se0/1.1, point2point, tags imposed: {20 30}
```

The following section of the output provides information about the second adjacency. For the second adjacency, no tag rewrite occurs as indicated by the entry “tag rewrite with , ,” and MPLS tags are not imposed on the packet indicated by the entry “tags imposed : {}.” The router also discards this packet indicated by the entry “valid discard adjacency.”

```
192.168.4.0/24, version 6, attached, connected
0 packets, 0 bytes
  tag information set
    local tag: 28
  via Loopback102, 0 dependencies
    valid discard adjacency
    tag rewrite with , , tags imposed: {}
192.168.4.0/32, version 4, receive
192.168.4.1/32, version 3, receive
192.168.4.255/32, version 5, receive
192.168.0.0/24, version 2, receive
255.255.255.255/32, version 1, receive
```

Step 3 **exit**

Use this command to exit to user EXEC mode. For example:

```
Router# exit
Router>
```

Configuration Examples for Basic Cisco Express Forwarding

There are no configuration examples for Cisco Express Forwarding. Cisco Express Forwarding is enabled by default.

Where to Go Next

If you want to disable Cisco Express Forwarding or distributed Cisco Express Forwarding operation, refer to *Enabling or Disabling Cisco Express Forwarding or distributed Cisco Express Forwarding to Customize Switching/Forwarding for Dynamic Networks.*

Additional References

The following sections provide references related to configuring basic Cisco Express Forwarding.

Related Documents

Related Topic	Document Title
List of the features documented in the Cisco Express Forwarding modules	*Cisco Express Forwarding Features Roadmap*
Overview of the Cisco Express Forwarding feature	*Cisco Express Forwarding Overview*

Related Topic	Document Title
Tasks for enabling or disabling Cisco Express Forwarding or distributed Cisco Express Forwarding	*Enabling or Disabling Cisco Express Forwarding or distributed Cisco Express Forwarding to Customize Switching/Forwarding for Dynamic Networks*
Tasks for configuring a load-balancing scheme for Cisco Express Forwarding	*Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic*
Tasks for configuring Cisco Express Forwarding consistency checkers	*Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards*
Tasks for configuring epochs for Cisco Express Forwarding tables	*Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables*
Tasks for configuring and verifying Cisco Express Forwarding network accounting	*Configuring Cisco Express Forwarding Network Accounting*
Tasks for customizing the display of recorded Cisco Express Forwarding events	*Customizing the Display of Recorded Cisco Express Forwarding Events*
Verification steps for Cisco Express Forwarding switching	*How to Verify Cisco Express Forwarding Switching*
Troubleshooting tips for incomplete adjacencies	*Troubleshooting Incomplete Adjacencies with CEF*
Description and use of the Cisco Express Forwarding consistency checkers available for the Cisco 7500 and 12000 series routers	*Troubleshooting Prefix Inconsistencies with Cisco Express Forwarding*
Information about troubleshooting Cisco Express Forwarding routing loops and suboptimal routing	*Troubleshooting Cisco Express Forwarding Routing Loops*
Causes of common Cisco Express Forwarding-related error messages on platforms running distributed Cisco Express Forwarding switching (Cisco 7500 series routers and Cisco 12000 Series Internet routers) and how to troubleshoot them	*Troubleshooting Cisco Express Forwarding-Related Error Messages*
Explanation of and troubleshooting information for the Cisco IOS software implementation of Layer 3 load balancing across multiple parallel links when Cisco Express Forwarding is used	*Troubleshooting Load Balancing Over Parallel Links Using Cisco Express Forwarding*
Troubleshooting guide for unicast IP routing on Catalyst 6500/6000 switches with Supervisor Engine 2, Policy Feature Card 2 (PFC2), or Multilayer Switch Feature Card 2 (MSFC2)	*Troubleshoot Unicast IP Routing Involving CEF on Catalyst 6500/6000 Series Switches with a Supervisor Engine 2 and Running CatOS System Software*
QoS features that require Cisco Express Forwarding	*When Is CEF Required for Quality of Service*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Feature Information for Configuring Basic Cisco Express Forwarding

Table 1 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Release 12.2(1) or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the *Cisco Express Forwarding Features Roadmap*.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 1 Feature Information for Configuring Basic Cisco Express Forwarding

Feature Name	Releases	Feature Configuration Information
CEF/dCEF - Cisco Express Forwarding	Cisco IOS XE Release 2.1	This feature was introduced on Cisco ASR 1000 Series Routers.

Glossary

adjacency—A relationship formed between selected neighboring routers and end nodes for the purpose of exchanging routing information. Adjacency is based upon the use of a common media segment by the routers and nodes involved.

Cisco Express Forwarding—A Layer 3 switching technology. Cisco Express Forwarding can also refer to central Cisco Express Forwarding mode, one of two modes of Cisco Express Forwarding operation. Cisco Express Forwarding enables a Route Processor (RP) to perform express forwarding. Distributed Cisco Express Forwarding is the other mode of Cisco Express Forwarding operation.

distributed Cisco Express Forwarding—A type of Cisco Express Forwarding switching in which line cards (such as Versatile Interface Processor (VIP) line cards) maintain identical copies of the forwarding information base (FIB) and adjacency tables. The line cards perform the express forwarding between port adapters; this relieves the Route Switch Processor of involvement in the switching operation.

FIB—forwarding information base. A component of Cisco Express Forwarding. The router uses the FIB lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The router maintains a mirror image of the forwarding information in an IP routing table.

IPC—interprocess communication. The mechanism that enables the distribution of Cisco Express Forwarding tables from the Route Switch Processor (RSP) to the line card when the router is operating in distributed Cisco Express Forwarding mode.

label disposition—The removal of Multiprotocol Label Switching (MPLS) headers at the edge of a network. In MPLS label disposition, packets arrive on a router as MPLS packets and, with the headers removed, are transmitted as IP packets.

label imposition—The action of putting a label on a packet.

LER—label edge router. A router that performs label imposition.

LFIB—label forwarding information base. The data structure used by switching functions to switch labeled packets.

LIB—label information base. A database used by a label switch router (LSR) to store labels learned from other LSRs, as well as labels assigned by the local LSR.

line card—A general term for an interface processor that can be used in various Cisco products. For example, a Versatile Interface Processor (VIP) is a line card for the Cisco 7500 series router.

LSP—label switched path. A sequence of hops (Router 0...Router n). A packet travels from R0 to Rn by means of label switching mechanisms. An LSP can be chosen dynamically, based on normal routing mechanisms, or it can be configured manually.

LSR—label switch router. A Layer 3 router that forwards a packet based on the value of a label encapsulated in the packet.

MPLS—Multiprotocol Label Switching. An emerging industry standard for the forwarding of packets along the normal routing paths (sometimes called MPLS hop-by-hop forwarding).

prefix—The network address portion of an IP address. A prefix is specified by a network and mask and is generally represented in the format network/mask. The mask indicates which bits are the network bits. For example, 1.0.0.0/16 means that the first 16 bits of the IP address are masked, making them the network bits. The remaining bits are the host bits. In this example, the network number is 10.0.

RIB—Routing Information Base. A central repository of routes that contains Layer 3 reachability information and destination IP addresses or prefixes. The RIB is also known as the routing table.

RP—Route Processor. The processor module in the Cisco 7000 series routers that contains the CPU, system software, and most of the memory components that are used in the router. It is sometimes called a supervisory processor.

RSP—Route Switch Processor. The processor module used in the Cisco 7500 series routers that integrates the functions of the Route Processor (RP) and the Switch Processor (SP).

SP—Switch Processor. Cisco 7000 series processor module that acts as the administrator for all CxBus activities. It is also sometimes called a CiscoBus controller.

VIP—Versatile Interface Processor. An interface card used in Cisco 7000 and Cisco 7500 series routers. The VIP provides multilayer switching and runs Cisco IOS.

VPN—Virtual Private Network. The result of a router configuration that enables IP traffic to use tunneling to travel securely over a public TCP/IP network.

VRF—A Virtual Private Network (VPN) routing/forwarding instance. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table. In general, a VRF includes the routing information that defines a customer VPN site that is attached to a PE router.

Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding to Customize Switching and Forwarding for Dynamic Networks

First Published: May 2, 2005
Last Updated: July 11, 2008

This module contains information about Cisco Express Forwarding and describes the required and optional tasks for enabling or disabling Cisco Express Forwarding and distributed Cisco Express Forwarding. Cisco Express Forwarding is an advanced Layer 3 IP switching technology. It optimizes network performance and scalability for all kinds of networks: those that carry small amounts of traffic and those that carry large amounts of traffic in complex patterns, such as the Internet and networks characterized by intensive web-based applications or interactive sessions.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding" section on page 13.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

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

Prerequisites for Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding

Cisco Express Forwarding requires a software image that includes Cisco Express Forwarding and IP routing enabled on the switch or router.

Restrictions for Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding

Central Cisco Express Forwarding or distributed Cisco Express Forwarding has the following restrictions:

- The Cisco 12000 Series Internet routers operate only in distributed Cisco Express Forwarding mode.
- If you enable Cisco Express Forwarding and then create an access list that uses the **log** keyword, the packets that match the access list are not Cisco Express Forwarding switched. They are process switched. Logging disables Cisco Express Forwarding.
- Distributed Cisco Express Forwarding switching cannot be configured on the same Versatile Interface Processor (VIP) card on which distributed fast switching is configured.
- Distributed Cisco Express Forwarding is not supported on Cisco 7200 series routers.

Restrictions for Cisco Express Forwarding or Distributed Cisco Express Forwarding Operation on an Interface

- On the Cisco 12000 Series Internet Router, you must not disable distributed Cisco Express Forwarding on an interface.
- Not all switching methods are available on all platforms.

Information About Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding

Before enabling or disabling Cisco Express Forwarding or distributed Cisco Express Forwarding, you should understand the following:

For links to information about other Cisco Express Forwarding and distributed Cisco Express Forwarding features you can configure, refer to the following section:

Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding

Cisco Express Forwarding is enabled by default on most Cisco platforms running Cisco IOS software Release12.0 or later. When Cisco Express Forwarding is enabled on a router, the Route Processor (RP) performs the express forwarding.

To find out if Cisco Express Forwarding is enabled on your platform, enter the **show ip cef** command. If Cisco Express Forwarding is enabled, you receive output that looks like this:

```
Router# show ip cef

Prefix              Next Hop            Interface
[...]
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
                    192.168.101.1       FastEthernet6/1
[...]
```

If Cisco Express Forwarding is not enabled on your platform, the output for the **show ip cef** command looks like this:

```
Router# show ip cef

%CEF not running
```

Distributed Cisco Express Forwarding is enabled by default on the Catalyst 6500 series switch, the Cisco 7500 series router, and the Cisco 12000 Series Internet Router. When distributed Cisco Express Forwarding is enabled on your platform, the line cards perform the express forwarding.

If Cisco Express Forwarding is not enabled on your platform, use the **ip cef** command to enable central Cisco Express Forwarding or the **ip cef distributed** command to enable distributed Cisco Express Forwarding.

When to Enable or Disable Central Cisco Express Forwarding Operation on a Router

Enable central Cisco Express Forwarding operation when line cards are not available for Cisco Express Forwarding switching or when you need to use features not compatible with distributed Cisco Express Forwarding switching. When central Cisco Express Forwarding operation is enabled, the Cisco Express Forwarding Forwarding Information Base (FIB) and adjacency tables reside on the RP, and the RP performs express forwarding.

Disable central Cisco Express Forwarding on a router when you want to turn off central Cisco Express Forwarding on the router and on all interfaces on the router. You might want to do this if your router and router interfaces are configured with a feature that central Cisco Express Forwarding or distributed Cisco Express Forwarding does not support.

To disable central Cisco Express Forwarding on a router and on all interfaces on the router, use the **no ip cef** command.

When to Enable Distributed Cisco Express Forwarding Operation on a Line Card

Enable distributed Cisco Express Forwarding on a line card when you want the line card to perform express forwarding so that the RP can handle routing protocols or switch packets from legacy interface processors. When distributed Cisco Express Forwarding is enabled, line cards, such as the VIP line cards or the Cisco 12000 Series Internet Router line cards, maintain an identical copy of the FIB and adjacency tables. The line cards perform express forwarding between port adapters, thus relieving the RP of involvement in the switching operation. distributed Cisco Express Forwarding uses an interprocess communication (IPC) mechanism to ensure synchronization of FIB tables and adjacency tables on the RP and line cards.

The Cisco 12000 Series Internet routers operate only in distributed Cisco Express Forwarding mode. In other routers you can mix various types of line cards in the same router, and all of the line cards you are using need not support Cisco Express Forwarding. When a line card that does not support Cisco Express Forwarding receives a packet, the line card forwards the packet to the next higher switching layer (the RP) or forwards the packet to the next hop for processing. This structure allows legacy interface processors to exist in the router with newer interface processors.

Note When you enable distributed Cisco Express Forwarding globally, all interfaces that support distributed Cisco Express Forwarding are enabled by default.

When to Enable or Disable Cisco Express Forwarding Operation on an Interface

You need to decide whether or not you want Cisco Express Forwarding operation on an interface. In some instances, you might want to disable Cisco Express Forwarding or distributed Cisco Express Forwarding on a particular interface because that interface is configured with a feature that Cisco Express Forwarding or distributed Cisco Express Forwarding does not support. Because all interfaces that support Cisco Express Forwarding or distributed Cisco Express Forwarding are enabled by default when you enable Cisco Express Forwarding operation globally, you must use the **no** form of the **ip route-cache cef** command to turn off Cisco Express Forwarding operation on a particular interface. To reenable Cisco Express Forwarding, use the **ip route-cache cef** command. To reenable distributed Cisco Express Forwarding, use the **ip route-cache distributed** command.

Disabling Cisco Express Forwarding or distributed Cisco Express Forwarding on an interface disables Cisco Express Forwarding switching for packets forwarded to the interface, but has no effect on packets forwarded out of the interface.

When you disable Cisco Express Forwarding or distributed Cisco Express Forwarding, Cisco IOS software switches packets received on the interface using the next fastest switching path. For Cisco Express Forwarding, the next fastest switching path is fast switching on the RP. For distributed Cisco Express Forwarding, the next fastest switching path is Cisco Express Forwarding on the RP.

The input interface determines the Cisco IOS switching path that a packet takes. Consider the following rules of thumb when enabling or disabling switching methods on a particular interface:

- You need Cisco Express Forwarding to be enabled on the incoming interface for packets to be Cisco Express Forwarding switched.
- Because Cisco Express Forwarding makes the forwarding decision on input, you need to use the **no ip route-cache cef** command on the ingress interface if you want to disable Cisco Express Forwarding.
- In contrast, because Cisco IOS builds a fast-switching cache entry after switching a packet, a packet coming in on a process-switched interface and going out through a fast-switched interface is fast switched.
- If you want to disable fast switching, use the **no ip route-cache** command on the egress interface.

How to Enable or Disable Central Cisco Express Forwarding or Distributed Cisco Express Forwarding

To enable or disable Cisco Express Forwarding or distributed Cisco Express Forwarding, perform either of the following tasks depending on whether you want to enable or disable Cisco Express Forwarding or distributed Cisco Express Forwarding on the router or to enable or disable Cisco Express Forwarding or distributed Cisco Express Forwarding on an interface:

- Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding Operation on a Router, page 5 (optional)
- Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding Operation on an Interface, page 7 (optional)

Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding Operation on a Router

Perform the following task to enable or disable Cisco Express Forwarding or distributed Cisco Express Forwarding operation on a router. Cisco Express Forwarding can optimize your network performance and scalability.

SUMMARY STEPS

1. **enable**
2. **show ip cef** [**vrf** *vrf-name*] [**unresolved** [**detail**]] | [**detail** | **summary**]]
3. **configure terminal**

4. **[no] ip cef**
   or
   [no] ip cef distributed
5. **exit**
6. **show ip cef** [**vrf** *vrf-name*] [**unresolved** [**detail**] | [**detail** | **summary**]]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show ip cef** [**vrf** *vrf-name*] [**unresolved** [**detail**]]	[**detail**	[**summary**]] **Example:** `Router# show ip cef`	Displays entries in the forwarding information base (FIB). Use this command to determine if Cisco Express Forwarding is enabled globally and on a particular interface. If Cisco Express Forwarding is not enabled, the output displays: `%CEF not running`
Step 3	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

Step 4	[**NO**] **ip cef**
	or
	[**NO**] **ip cef distributed**
	
	Example:
	`Router(config)# ip cef`
	or
	
	Example:
	`Router(config)# ip cef distributed`
		Enables Cisco Express Forwarding on the route processor card.
		or
		Enables distributed Cisco Express Forwarding operation. Cisco Express Forwarding information is distributed to line cards. Line cards perform express forwarding.

Step 5	**exit** **Example:** `Router(config)# end`	Exits to privileged EXEC mode.
Step 6	**show ip cef** [**vrf** *vrf-name*] [**unresolved** [**detail**]	[**detail**	**summary**]] **Example:** `Router# show ip cef`	Displays entries in the FIB. Use this command to verify that Cisco Express Forwarding is enabled. If Cisco Express Forwarding is enabled, the output displays destination prefixes, next-hop IP addresses, and next-hop interfaces.

Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding Operation on an Interface

Perform the following task to enable or disable Cisco Express Forwarding or distributed Cisco Express Forwarding operation on an interface. Cisco Express Forwarding can optimize your network performance and scalability.

SUMMARY STEPS

1. **enable**
2. **show cef interface** [*type number*] [**statistics**] [**detail**]
3. **configure terminal**
4. **interface** *type slot*/*port* or **interface** *type slot*/*port-adapter*/*port*
5. [**no**] **ip route-cache cef** or **ip route-cache cef**

   or

   [**no**] **ip route-cache distributed**
6. **end**
7. **show cef interface** [*type number*] [**statistics**] [**detail**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show cef interface** [*type number*] [**statistics**] [**detail**] **Example:** `Router# show cef interface fastethernet 1/0/0`	Displays detailed Cisco Express Forwarding information for a specified interface or for all interfaces. Look for “IP CEF switching enabled” or “IP Distributed CEF switching enabled” in the output.
Step 3	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 4	**interface** type slot/port or **interface** type slot/port-adapter/port **Example:** Router(config)# interface ethernet 1/1 or Router(config)# interface fastethernet 1/0/0	Configures an interface type and enters interface configuration mode. • The *type* argument specifies the type of interface to be configured. • The *slot*/ argument specifies the slot number. Refer to the appropriate hardware manual for slot and port information. • The *port* argument specifies the port number. Refer to the appropriate hardware manual for slot and port information. • The *port-adapter*/ argument specifies the port adapter number. Refer to the appropriate hardware manual for information about port adapter compatibility.
Step 5	[**no**] **ip route-cache cef** or [**no**] **ip route-cache distributed** **Example:** Router(config-if)# no ip route-cache cef or **Example:** Router(config-if)# no ip route-cache distributed	Disables Cisco Express Forwarding operation on an interface or enables Cisco Express Forwarding operation on an interface after Cisco Express Forwarding operation was disabled. or Disables distributed Cisco Express Forwarding operation on an interface or enables distributed Cisco Express Forwarding operation on an interface after distributed Cisco Express Forwarding operation was disabled.
Step 6	**end** **Example:** Router(config)# end	Exits to privileged EXEC mode.
Step 7	**show cef interface** [*type number*] [**statistics**] [**detail**] **Example:** Router# show cef interface fastethernet 1/0/0	Displays detailed Cisco Express Forwarding information for a specified interface or for all interfaces. Verify that “IP CEF switching enabled” or “IP Distributed CEF switching enabled” is displayed in the output.

Configuration Examples for Enabling or Disabling Central Cisco Express Forwarding or Distributed Cisco Express Forwarding

This section contains the following configuration examples:

- Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding Operation: Examples, page 9
- Enabling or Disabling Central Cisco Express Forwarding or Distributed Cisco Express Forwarding Operation on an Interface: Examples, page 9

Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding Operation: Examples

Cisco Express Forwarding is enabled by default on the Cisco 7100, 7200, and 7500 series routers. You might want to disable Cisco Express Forwarding if your router and router interfaces are configured with a feature that Cisco Express Forwarding does not support. The following example shows how to disable Cisco Express Forwarding on a router and on all interfaces on the router:

```
configure terminal
!
no ip cef
end
```

Distributed Cisco Express Forwarding is enabled by default on the Cisco 6500 and 12000 series routers. The following example shows how to enable distributed Cisco Express Forwarding on the line cards of a router, such as the Cisco 7500 series router, that supports distributed Cisco Express Forwarding:

```
configure terminal
!
ip cef distributed
end
```

You might want to disable distributed Cisco Express Forwarding if your router and router interfaces are configured with a feature that distributed Cisco Express Forwarding does not support. The following example shows how to disable distributed Cisco Express Forwarding on a router:

```
configure terminal
!
no ip cef distributed
end
```

Enabling or Disabling Central Cisco Express Forwarding or Distributed Cisco Express Forwarding Operation on an Interface: Examples

All interfaces that support Cisco Express Forwarding operation (central Cisco Express Forwarding or distributed Cisco Express Forwarding) are enabled by default when you enable Cisco Express Forwarding operation globally. You might want to disable central Cisco Express Forwarding or distributed Cisco Express Forwarding on a particular interface if that interface is configured with a feature that central Cisco Express Forwarding or distributed Cisco Express Forwarding does not support.

The following example shows how to disable central Cisco Express Forwarding on a particular interface:

```
configure terminal
!
interface ethernet 1/1
 no ip route-cache cef
 end
```

The following example shows how to reenable central Cisco Express Forwarding operation on an interface:

```
configure terminal
!
interface ethernet 1/1
 ip route-cache cef
 end
```

The following example shows how to disable distributed Cisco Express Forwarding on Ethernet interface 0:

```
configure terminal
!
interface e0
 no ip route-cache distributed
 end
```

The following example shows how to reenable distributed Cisco Express Forwarding operation on Ethernet interface 0:

```
configure terminal
!
ip cef distributed
!
interface e0
# ip route-cache distributed
 end
```

The following example shows how to enable Cisco Express Forwarding operation on the router (globally) and turn off Cisco Express Forwarding operation on Ethernet interface 0:

```
configure terminal
!

ip cef
!
interface e0
 no ip route-cache cef
 end
```

The following example shows how to enable distributed Cisco Express Forwarding operation on the router (globally) and turn off Cisco Express Forwarding operation on Ethernet interface 0:

```
configure terminal
!
ip cef distributed

interface e0
 no ip route-cache cef
 end
```

The following example shows how to reenable distributed Cisco Express Forwarding operation on Ethernet interface 0:

```
configure terminal
!
ip cef distributed
!
interface e0
 ip route-cache distributed
 end
```

Additional References

The following sections provide references related to enabling or disabling central Cisco Express Forwarding or distributed Cisco Express Forwarding.

Related Documents

Related Topic	Document Title
List of the features documented in the Cisco Express Forwarding modules	*Cisco Express Forwarding Features Roadmap*
Overview of the Cisco Express Forwarding feature	*Cisco Express Forwarding Overview*
Tasks for verifying Cisco Express Forwarding information on your router	*Configuring Basic Cisco Express Forwarding for Improved Performance, Scalability, and Resiliency in Dynamic Networks*
Tasks for configuring a load-balancing scheme for Cisco Express Forwarding	*Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic*
Tasks for configuring Cisco Express Forwarding consistency checkers	*Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards*
Tasks for configuring epochs for Cisco Express Forwarding tables	*Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables*
Tasks for configuring and verifying Cisco Express Forwarding network accounting	*Configuring Cisco Express Forwarding Network Accounting*
Tasks for customizing the display of recorded Cisco Express Forwarding events	*Customizing the Display of Recorded Cisco Express Forwarding Events*
Troubleshooting tips for incomplete adjacencies	*Troubleshooting Incomplete Adjacencies with CEF*
Description and use of the Cisco Express Forwarding consistency checkers available for the Cisco 7500 and 12000 series routers	*Troubleshooting Prefix Inconsistencies with Cisco Express Forwarding*
Information about troubleshooting Cisco Express Forwarding routing loops and suboptimal routing	*Troubleshooting Cisco Express Forwarding Routing Loops*
Causes of common Cisco Express Forwarding-related error messages on platforms running distributed Cisco Express Forwarding switching (Cisco 7500 series routers and Cisco 12000 Series Internet routers) and how to troubleshoot them	*Troubleshooting Cisco Express Forwarding-Related Error Messages*
Explanation of and troubleshooting information for the Cisco IOS software implementation of Layer 3 load balancing across multiple parallel links when Cisco Express Forwarding is used	*Troubleshooting Load Balancing Over Parallel Links Using Cisco Express Forwarding*
Troubleshooting guide for unicast IP routing on Catalyst 6500/6000 switches with Supervisor Engine 2, Policy Feature Card 2 (PFC2), or Multilayer Switch Feature Card 2 (MSFC2)	*Troubleshoot Unicast IP Routing Involving CEF on Catalyst 6500/6000 Series Switches with a Supervisor Engine 2 and Running CatOS System Software*
QoS features that require Cisco Express Forwarding	*When Is CEF Required for Quality of Service*
Cisco Express Forwarding command changes for MPLS HA application and the MFI infrastructure in Cisco IOS 12.2S releases	*Cisco Express Forwarding: Command Changes*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Feature Information for Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding

Table 1 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Release 12.2(1) or 12.0(3)S or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the *Cisco Express Forwarding Features Roadmap*.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 1 Feature Information for Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding

Feature Name	Releases	Feature Configuration Information
This table is intentionally left blank because no features were introduced or modified in Cisco IOS Release 12.2(1) or later. This table will be updated when feature information is added to this module.	—	—

Glossary

adjacency—A relationship formed between selected neighboring routers and end nodes for the purpose of exchanging routing information. Adjacency is based upon the use of a common media segment by the routers and nodes involved.

Cisco Express Forwarding—A Layer 3 switching technology. Cisco Express Forwarding can also refer to central Cisco Express Forwarding mode, one of two modes of Cisco Express Forwarding operation. Cisco Express Forwarding enables a Route Processor to perform express forwarding. Distributed Cisco Express Forwarding is the other mode of Cisco Express Forwarding operation.

distributed Cisco Express Forwarding—A mode of Cisco Express Forwarding operation in which line cards (such as Versatile Interface Processor (VIP) line cards) maintain identical copies of the forwarding information base (FIB) and adjacency tables. The line cards perform the express forwarding between port adapters; this relieves the Route Switch Processor of involvement in the switching operation.

FIB—forwarding information base. A component of Cisco Express Forwarding that is conceptually similar to a routing table or information base. The router uses the FIB lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The router maintains a mirror image of the forwarding information in an IP routing table.

GRE—generic routing encapsulation. A tunneling protocol developed by Cisco that enables encapsulation of a wide variety of protocol packet types inside IP tunnels. GRE creates a virtual point-to-point link to Cisco routers at remote points over an IP internetwork. By connecting multiprotocol subnetworks in a single-protocol backbone environment, IP tunneling using GRE allows the expansion of a network across a single-protocol backbone environment.

IPC—interprocess communication. The mechanism that enables the distribution of Cisco Express Forwarding tables from the Route Switch Processor (RSP) to the line card when the router is operating in distributed Cisco Express Forwarding mode.

label disposition—The removal of Multiprotocol Label Switching (MPLS) headers at the edge of a network. In MPLS label disposition, packets arrive on a router as MPLS packets and, with the header removed, are transmitted as IP packets.

label imposition—The action of putting a label on a packet.

LER—label edge router. A router that performs label imposition.

LFIB—Label Forwarding Information Base. The data structure used by switching functions to switch labeled packets.

LIB—Label information base. A database used by a label switch router (LSR) to store labels learned from other LSRs, as well as labels assigned by the local LSR.

line card—A general term for an interface processor that can be used in various Cisco products. For example, a Versatile Interface Processor (VIP) is a line card for the Cisco 7500 series router.

LSP—label switched path. A sequence of hops (Router 0...Router n). A packet travels from R0 to Rn by means of label switching mechanisms. An LSP can be chosen dynamically, based on normal routing mechanisms, or you can configure the LSP manually.

LSR—label switch router. A Layer 3 router that forwards a packet based on the value of a label encapsulated in the packet.

MPLS—Multiprotocol Label Switching. An emerging industry standard for the forwarding of packets along the normal routing paths (sometimes called MPLS hop-by-hop forwarding).

prefix—The network address portion of an IP address. A prefix is specified by a network and mask and is generally represented in the format network/mask. The mask indicates which bits are the network bits. For example, 1.0.0.0/16 means that the first 16 bits of the IP address are masked, making them the network bits. The remaining bits are the host bits. In this example, the network number is 10.0.

RIB—Routing Information Base. A central repository of routes that contains Layer 3 reachability information and destination IP addresses or prefixes. The RIB is also known as the routing table.

RP—Route Processor. The processor module in the Cisco 7000 series routers that contains the CPU, system software, and most of the memory components that are used in the router. It is sometimes called a supervisory processor.

RSP—Route Switch Processor. The processor module used in the Cisco 7500 series routers that integrates the functions of the Route Processor (RP) and the Switch Processor (SP).

SP—Switch Processor. Cisco 7000-series processor module that acts as the administrator for all CxBus activities. It is also sometimes called a CiscoBus controller.

VIP—Versatile Interface Processor. An interface card used in Cisco 7000 and Cisco 7500 series routers. The VIP provides multilayer switching and runs Cisco IOS software.

VPN—Virtual Private Network. The result of a router configuration that enables IP traffic to use tunneling to travel securely over a public TCP/IP network.

VRF—A Virtual Private Network (VPN) routing/forwarding instance. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table. In general, a VRF includes the routing information that defines a customer VPN site that is attached to a PE router.

Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

First Published: May 2, 2005
Last Updated: July 11, 2008

This module contains information about Cisco Express Forwarding and describes the required and optional tasks for configuring a load-balancing scheme for Cisco Express Forwarding traffic. Load-balancing allows you to optimize resources by distributing traffic over multiple paths.

Cisco Express Forwarding is an advanced Layer 3 IP switching technology. It optimizes network performance and scalability for all kinds of networks: those that carry small amounts of traffic and those that carry large amounts of traffic in complex patterns, such as the Internet and networks characterized by intensive web-based applications or interactive sessions.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic" section on page 17.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

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

Prerequisites for Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

- Cisco Express Forwarding or distributed Cisco Express Forwarding must be enabled on your switch or router.
- If you enable per-packet load balancing for traffic going to a particular destination, all interfaces that can forward traffic to that destination must be enabled for per-packet load balancing.

Restrictions for Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

You must globally configure load balancing on Cisco 12000 Series Router E2 line cards in the same way: either in per-destination or per-packet mode. It is not possible (as in other Cisco IOS software-based platforms) to configure some packet prefixes in per-destination mode and others in per-packet mode.

Information About Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

Before configuring a load-balancing scheme for Cisco Express Forwarding traffic, you should understand the following concepts:

- Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding, page 3
- Cisco Express Forwarding Load-Balancing Overview, page 3
- Per-Destination Load Balancing for Cisco Express Forwarding Traffic, page 3
- Per-Packet Load Balancing for Cisco Express Forwarding Traffic, page 4
- Load-Balancing Algorithms for Cisco Express Forwarding Traffic, page 4

For links to information about other Cisco Express Forwarding and distributed Cisco Express Forwarding features that you can configure, see the "Additional References" section on page 14.

Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding

Cisco Express Forwarding is enabled by default on most Cisco platforms running Cisco IOS software Release 12.0 or later. When Cisco Express Forwarding is enabled on a router, the Route Processor (RP) performs the express forwarding.

To find out if Cisco Express Forwarding is enabled on your platform, enter the **show ip cef** command. If Cisco Express Forwarding is enabled, you receive output that looks like this:

```
Router# show ip cef

Prefix              Next Hop            Interface
[...]
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
                    192.168.101.1       FastEthernet6/1
[...]
```

If Cisco Express Forwarding is not enabled on your platform, the output for the **show ip cef** command looks like this:

```
Router# show ip cef

%CEF not running
```

Distributed Cisco Express Forwarding is enabled by default on the Catalyst 6500 series switch, the Cisco 7500 series router, and the Cisco 12000 series router. When distributed Cisco Express Forwarding is enabled on your platform, the line cards perform the express forwarding.

If Cisco Express Forwarding is not enabled on your platform, use the **ip cef** command to enable (central) Cisco Express Forwarding or the **ip cef distributed** command to enable distributed Cisco Express Forwarding.

Cisco Express Forwarding Load-Balancing Overview

Cisco Express Forwarding load balancing is based on a combination of source and destination packet information; it allows you to optimize resources by distributing traffic over multiple paths.

You can configure load balancing on a per-destination or per-packet basis. Because load-balancing decisions are made on the outbound interface, load balancing must be configured on the outbound interface.

Per-Destination Load Balancing for Cisco Express Forwarding Traffic

Per-destination load balancing allows the router to use multiple paths to achieve load sharing across multiple source-destination host pairs. Packets for a given source-destination host pair are guaranteed to take the same path, even if multiple paths are available. Traffic streams destined for different pairs tend to take different paths.

Per-destination load balancing is enabled by default when you enable Cisco Express Forwarding. To use per-destination load balancing, you do not perform any additional tasks once Cisco Express Forwarding is enabled. Per-destination is the load-balancing method of choice for most situations.

Because per-destination load balancing depends on the statistical distribution of traffic, load sharing becomes more effective as the number of source-destination host pairs increases.

You can use per-destination load balancing to ensure that packets for a given host pair arrive in order. All packets intended for a certain host pair are routed over the same link (or links).

Typically, you disable per-destination load balancing when you want to enable per-packet load balancing.

Note The Cisco 10000 series router and the Cisco 12000 series router are configured by default to perform per-destination load balancing.

Per-Packet Load Balancing for Cisco Express Forwarding Traffic

Cisco Express Forwarding Per-packet load balancing allows the router to send successive data packets over different paths without regard to individual hosts or user sessions. It uses the round-robin method to determine which path each packet takes to the destination. Per-packet load balancing ensures that the traffic is balanced over multiple links.

Per-packet load balancing is good for single-path destinations, but packets for a given source-destination host pair might take different paths. Per-packet load balancing can therefore introduce reordering of packets. This type of load balancing is inappropriate for certain types of data traffic (such as voice traffic over IP) that depend on packets arriving at the destination in sequence.

Use per-packet load balancing to help ensure that a path for a single source-destination host pair does not get overloaded. If the bulk of the data passing through parallel links is for a single pair, per-destination load balancing overloads a single link while other links have very little traffic. Enabling per-packet load balancing allows you to use alternate paths to the same busy destination.

Load-Balancing Algorithms for Cisco Express Forwarding Traffic

The following load-balancing algorithms are provided for use with Cisco Express Forwarding traffic. You select a load-balancing algorithm with the **ip cef load-sharing algorithm** command.

- Original algorithm—The original Cisco Express Forwarding load-balancing algorithm produces distortions in load sharing across multiple routers because the same algorithm was used on every router. Depending on your network environment, you should select either the universal algorithm (default) or the tunnel algorithm instead.
- Universal algorithm—The universal load-balancing algorithm allows each router on the network to make a different load sharing decision for each source-destination address pair, which resolves load-sharing imbalances. The router is set to perform universal load sharing by default.
- Tunnel algorithm—The tunnel algorithm is designed to balance the per-packet load when only a few source and destination pairs are involved.
- Include-ports algorithm—The include-ports algorithm allows you to use the Layer 4 source and destination ports as part of the load-balancing decision. This method benefits traffic streams running over equal cost paths that are not load shared because the majority of the traffic is between peer addresses that use different port numbers, such as Real-Time Protocol (RTP) streams. The include-ports algorithm is available in Cisco IOS Release 12.4(11)T and later releases.

How to Configure a Load-Balancing Scheme for Cisco Express Forwarding Traffic

Perform the following tasks to configure and fine-tune load balancing for Cisco Express Forwarding:

- Enabling or Disabling Cisco Express Forwarding Per-Destination Load Balancing, page 5 (optional)
- Configuring Cisco Express Forwarding Per-Packet Load Balancing, page 6 (optional)
- Selecting a Cisco Express Forwarding Load-Balancing Algorithm, page 7 (optional)

Enabling or Disabling Cisco Express Forwarding Per-Destination Load Balancing

Perform this task to enable or disable Cisco Express Forwarding per-destination load balancing.

Typically, you disable per-destination load balancing when you want to enable per-packet load balancing.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type slot/port* or **interface** *type slot/port-adapter/port*
4. [**no**] **ip cef load-sharing** [**per-packet**] [**per-destination**]
5. end

DETAILED STEPS

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

	Command or Action	Purpose
Step 3	**interface** type slot/port or **interface** type slot/port-adapter/port **Example:** Router(config)# interface ethernet 1/1 or **Example:** Router(config)# interface fastethernet 1/0/0	Configures an interface type and enters interface configuration mode. • The *type* argument specifies the type of interface to be configured. • The *slot* argument specifies the slot number. Refer to the appropriate hardware manual for slot and port information. • The *port* argument specifies the port number. Refer to the appropriate hardware manual for slot and port information. • The *port-adapter* argument specifies the port adapter number. Refer to the appropriate hardware manual for information about port adapter compatibility. **Note** The slashes after the *slot* argument and *port-adapter* argument are required.
Step 4	[**no**] **ip cef load-sharing** [**per-packet**] [**per-destination**] **Example:** Router(config-if)# no ip cef load-sharing per-destination	Enables load balancing for Cisco Express Forwarding. • The **no ip cef load-sharing** command disables Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic load balancing. • The **per-packet** keyword enables per-packet load balancing on the interface. • The **per-destination** keyword enables per-destination load balancing on the interface.
Step 5	**end** **Example:** Router(config-if)# end	Exits to privileged EXEC mode.

Configuring Cisco Express Forwarding Per-Packet Load Balancing

Perform the following task to configure Cisco Express Forwarding per-packet load balancing.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type slot*/*port* or **interface** *type slot*/*port-adapter*/*port*
4. [**no**] **ip load-sharing** [**per-packet**] [**per-destination**]
5. end

DETAILED STEPS

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

Step 3	**interface** type slot/port
	or
	interface type slot/port-adapter/port
	
	Example:
	`Router(config)# interface ethernet 1/1`
	or
	`Router(config)# interface fastethernet 1/0/0`
		Configures an interface type and enters interface configuration mode.
		• The *type* argument specifies the type of interface to be configured.
		• The *slot* argument specifies the slot number. Refer to the appropriate hardware manual for slot and port information.
		• The *port* argument specifies the port number. Refer to the appropriate hardware manual for slot and port information.
		• The *port-adapter* argument specifies the port adapter number. Refer to the appropriate hardware manual for information about port adapters.
		Note The slashes after the *slot* argument and *port-adapter* argument are required.

Step 4	[**no**] **ip load-sharing** [**per-packet**] [**per-destination**] **Example:** `Router(config-if)# ip load-sharing per-packet`	Enables load balancing for Cisco Express Forwarding. • The **per-packet** keyword enables per-packet load balancing on the interface. • The **per-destination** keyword enables per-destination load balancing on the interface.
Step 5	**end** **Example:** `Router(config-if)# end`	Exits to privileged EXEC mode.

Selecting a Cisco Express Forwarding Load-Balancing Algorithm

Perform one of the following tasks to elect a Cisco Express Forwarding load-balancing algorithm.

- Selecting a Tunnel Load-Balancing Algorithm for Cisco Express Forwarding Traffic, page 8
- Selecting an Include-Ports Layer 4 Load-Balancing Algorithm for Cisco Express Forwarding Traffic, page 9

The router is set to perform universal load sharing by default.

Selecting a Tunnel Load-Balancing Algorithm for Cisco Express Forwarding Traffic

Perform the following task to select a tunnel load-balancing algorithm for Cisco Express Forwarding traffic. Select the tunnel algorithm when your network environment contains only a few source and destination pairs.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef load-sharing algorithm** {**original** | **tunnel** [*id*] | **universal** [*id*] | **include-ports** {**source** [*id*] | [**destination**] [*id*] | **source** [*id*] **destination** [*id*]}}
4. **end**

DETAILED STEPS

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

	Command or Action	Purpose
Step 3	**ip cef load-sharing algorithm** {**original** | **tunnel** [*id*] | **universal** [*id*] | **include-ports** {**source** [*id*]| [**destination**] [*id*] | **source** [*id*] **destination** [*id*]}} **Example:** `Router(config)# ip cef load-sharing algorithm tunnel`	Selects a Cisco Express Forwarding load-balancing algorithm. • The **original** keyword sets the load-balancing algorithm to the original algorithm, based on a source and destination hash. • The **tunnel** keyword sets the load-balancing algorithm to one that can be used in tunnel environments or in environments where there are only a few IP source and destination address pairs. • The *id* argument is a fixed identifier. • The **universal** keyword sets the load-balancing algorithm to one that uses a source and destination and an ID hash. • The **include-ports source** keywords set the load-balancing algorithm to one that uses the source port. • The **include-ports destination** keywords set the load-balancing algorithm to one that uses the destination port. • The **include-ports source destination** keywords set the load-balancing algorithm to one that uses both source and destination ports.
Step 4	**end** **Example:** `Router(config)# end`	Exits to privileged EXEC mode.

Selecting an Include-Ports Layer 4 Load-Balancing Algorithm for Cisco Express Forwarding Traffic

Perform the following task to select an include-ports load-balancing algorithm for Cisco Express Forwarding traffic. Select the include-port algorithm when your network environment contains traffic running over equal-cost paths that is not load shared because the majority of the traffic is between peer addresses with different port numbers, such as RTP streams.

Prerequisites

Your system must be using an image that supports Cisco Express Forwarding in Cisco IOS Release 12.4(11)T or a later release.

Restrictions

The Layer 4 load-balancing algorithm applies to software switched packets.

For platforms that switch traffic using a hardware forwarding engine, the hardware load-balancing decision might be different from the software load-balancing decision for the same traffic stream. You might want to override the configured algorithm.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef load-sharing algorithm** {**original** | **tunnel** [*id*] | **universal** [*id*] | | **include-ports** {**source** [*id*] | [**destination**] [*id*] | **source** [*id*] **destination** [*id*]}}
4. **end**

DETAILED STEPS

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

	Command or Action	Purpose
Step 3	**ip cef load-sharing algorithm** {**original** | **tunnel** [*id*] | **universal** [*id*] **include-ports** {**source** [*id*] | [**destination**] [*id*] | **source** [*id*] **destination** [*id*]}} **Example:** `Router(config)# ip cef load-sharing algorithm include-ports source destination`	Selects a Cisco Express Forwarding load-balancing algorithm. • The **original** keyword sets the load-balancing algorithm to the original algorithm, based on a source and destination hash. • The **tunnel** keyword sets the load-balancing algorithm to one that can be used in tunnel environments or in environments where there are only a few IP source and destination address pairs. • The *id* argument is a fixed identifier. • The **universal** keyword sets the load-balancing algorithm to one that uses a source and destination and an ID hash. • The **include-ports source** keyword sets the load-balancing algorithm to one that uses the source port. • The **include-ports destination** keyword sets the load-balancing algorithm to one that uses the destination port. • The **include-ports source destination** keyword sets the load-balancing algorithm to one that uses the source and destination ports.
Step 4	**end** **Example:** `Router(config)# end`	Exits to privileged mode.

Configuration Examples for Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

This section provides the following examples for configuring a load-balancing scheme for Cisco Express Forwarding traffic:

- Enabling or Disabling Cisco Express Forwarding Per-Destination Load Balancing: Example, page 12
- Configuring Cisco Express Forwarding Per-Packet Load Balancing: Example, page 12
- Selecting a Cisco Express Forwarding Load-Balancing Algorithm: Example, page 12

Enabling or Disabling Cisco Express Forwarding Per-Destination Load Balancing: Example

Per-destination load balancing is enabled by default when you enable Cisco Express Forwarding. Typically, you disable per-destination load balancing when you want to enable per-packet load balancing. The following example shows how to disable per-destination load balancing:

```
configure terminal
!
interface ethernet 1/1
 no ip load-sharing per-destination
 end
```

Configuring Cisco Express Forwarding Per-Packet Load Balancing: Example

The following example shows how to configure per-packet load balancing for Cisco Express Forwarding:

```
configure terminal
!
interface ethernet 1/1
 ip load-sharing per-packet
 end
```

If you want to enable per-packet load balancing for traffic intended for a particular destination, all interfaces that can forward traffic to that destination must be enabled for per-packet load-balancing.

Selecting a Cisco Express Forwarding Load-Balancing Algorithm: Example

The router is set to perform universal load balancing by default.

The following examples show how to select a different Cisco Express Forwarding load-balancing algorithm:

- Selecting a Tunnel Load-Balancing Algorithm for Cisco Express Forwarding Traffic: Example, page 12
- Selecting an Include-Ports Layer 4 Load-Balancing Algorithm for Cisco Express Forwarding Traffic: Example, page 14

Selecting a Tunnel Load-Balancing Algorithm for Cisco Express Forwarding Traffic: Example

The following example shows how to select a tunnel load-balancing algorithm for Cisco Express Forwarding:

```
configure terminal
!
ip cef load-sharing algorithm tunnel
end
```

The following example shows how to disable the tunnel load-balancing algorithm:

```
configure terminal
!
no ip cef load-sharing algorithm tunnel
end
```

Selecting an Include-Ports Layer 4 Load-Balancing Algorithm for Cisco Express Forwarding Traffic: Example

The following example shows how to select an include-ports Layer 4 load-balancing algorithm for Cisco Express Forwarding traffic:

```
configure terminal
!
ip cef load-sharing algorithm include-ports source
end
```

This example sets up load sharing that includes the source port in the load-balancing decision.

To disable the include-ports Layer 4 load-balancing algorithm and return to the default universal mode, enter the following commands:

```
configure terminal
!
no ip cef load-sharing algorithm
end
```

Additional References

The following sections provide references related to configuring a load-balancing scheme for Cisco Express Forwarding traffic.

Related Documents

Related Topic	Document Title
Commands for configuring and managing Cisco Express Forwarding	*Cisco IOS IP Switching Command Reference*
List of the features documented in the Cisco Express Forwarding modules	*Cisco Express Forwarding Features Roadmap*
Overview of the Cisco Express Forwarding feature	*Cisco Express Forwarding Overview*
Tasks for verifying basic Cisco Express Forwarding and distributed Cisco Express Forwarding operation	*Configuring Basic Cisco Express Forwarding for Improved Performance, Scalability, and Resiliency in Dynamic Networks*
Tasks for enabling or disabling Cisco Express Forwarding or distributed Cisco Express Forwarding	*Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding to Customize Switching and Forwarding for Dynamic Networks*
Tasks for configuring Cisco Express Forwarding consistency checkers	*Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards*
Tasks for configuring epochs for Cisco Express Forwarding tables	*Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables*
Tasks for configuring and verifying Cisco Express Forwarding network accounting	*Configuring Cisco Express Forwarding Network Accounting*
Tasks for customizing the display of recorded Cisco Express Forwarding events	*Customizing the Display of Recorded Cisco Express Forwarding Events*

Related Topic	Document Title
Tasks for customizing the display of recorded Cisco Express Forwarding events	*Customizing the Display of Recorded Cisco Express Forwarding Events*
Explanation of and troubleshooting information for the Cisco IOS software implementation of Layer 3 load balancing across multiple parallel links when Cisco Express Forwarding is used	*Troubleshooting Load Balancing Over Parallel Links Using Cisco Express Forwarding*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Command Reference

The following commands are introduced or modified in the feature or features documented in this module. For information about these commands, see the *Cisco IOS <Technology> Command Reference* at http://www.cisco.com/en/US/docs/ios/ipswich/command/reference/isw_book.html. For information about all Cisco IOS commands, use the Command Lookup Tool at http://tools.cisco.com/Support/CLILookup or the *Cisco IOS Master Command List, All Releases*, at http://www.cisco.com/en/US/docs/ios/mcl/allreleasemcl/all_book.html.

- **ip cef load-sharing algorithm**
- **show ip cef exact-route**

Feature Information for Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

Table 1 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Release 12.2(1) or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the *Cisco Express Forwarding Features Roadmap*.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 1 Feature Information for Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

Feature Name	Releases	Feature Configuration Information
Cisco Express Forwarding Support for Layer 4 Port-Based Load Balancing	12.4(11)T	This feature allows Cisco Express Forwarding to include Layer 4 port information in the decision for load sharing on equal cost paths. In 12.4(11)T, this feature was introduced. The following sections provide information about this feature: • Load-Balancing Algorithms for Cisco Express Forwarding Traffic, page 4 • Selecting a Cisco Express Forwarding Load-Balancing Algorithm, page 7 The following commands were modified by this feature: **ip cef load-sharing algorithm** and **show ip cef exact-route**.

Glossary

adjacency—A relationship formed between selected neighboring routers and end nodes for the purpose of exchanging routing information. Adjacency is based upon the use of a common media segment by the routers and nodes involved.

Cisco Express Forwarding—A Layer 3 switching technology. Cisco Express Forwarding can also refer to central Cisco Express Forwarding mode, one of two modes of Cisco Express Forwarding operation. Cisco Express Forwarding enables a Route Processor to perform express forwarding. Distributed Cisco Express Forwarding is the other mode of Cisco Express Forwarding operation.

distributed Cisco Express Forwarding—A mode of Cisco Express Forwarding operation in which line cards (such as Versatile Interface Processor [VIP] line cards) maintain identical copies of the forwarding information base (FIB) and adjacency tables. The line cards perform the express forwarding between port adapters; this relieves the Route Switch Processor of involvement in the switching operation.

FIB—forwarding information base. A component of Cisco Express Forwarding that is conceptually similar to a routing table or information base. The router uses the FIB lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The router maintains a mirror image of the forwarding information in an IP routing table.

LSP—label switched path. A sequence of hops (Router 0...Router n). A packet travels from R0 to Rn by means of label switching mechanisms. An LSP can be chosen dynamically, based on normal routing mechanisms, or you can configure the LSP manually.

prefix—The network address portion of an IP address. A prefix is specified by a network and mask and is generally represented in the format network/mask. The mask indicates which bits are the network bits. For example, 1.0.0.0/16 means that the first 16 bits of the IP address are masked, making them the network bits. The remaining bits are the host bits. In this example, the network number is 10.0.

RIB—Routing Information Base. A central repository of routes that contains Layer 3 reachability.

Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables

First Published: May 2, 2005
Last Updated: February 11, 2008

This document contains information about and instructions for configuring epochs for Cisco Express Forwarding tables. You can use this functionality to clear and rebuild Cisco Express Forwarding tables for consistency purposes without the loss of table information.

Cisco Express Forwarding is an advanced Layer 3 IP switching technology. It optimizes network performance and scalability for all kinds of networks: those that carry small amounts of traffic and those that carry large amounts of traffic in complex patterns, such as the Internet and networks characterized by intensive web-based applications or interactive sessions.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables" section on page 13.

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Prerequisites for Configuring Basic Cisco Express Forwarding

Cisco Express Forwarding must be up and running on the router or switch for you to configure epochs for Cisco Express ForwardingCisco Express Forwarding FIB and adjacency tables.

Information About Configuring Basic Cisco Express Forwarding

Tasks for configuring epochs for Cisco Express Forwarding Forwarding Information Base (FIB) tables were introduced with the Nonstop Forwarding Enhanced FIB Refresh feature in Cisco IOS Release 12.2(8)T.

Before you configure epochs for Cisco Express Forwarding tables, you should understand the following:

- Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding, page 2
- Nonstop Forwarding Enhanced FIB Refresh (Cisco IOS 12.2(8)T), page 3
- Epoch Numbering for Cisco Express Forwarding FIB and Adjacency Tables, page 3
- Epoch Synchronization Between the RP and Line Cards, page 4
- Epoch Numbering for Routers That Support High Availability, page 4
- When to Refresh the Cisco Express Forwarding or Adjacency Tables, page 4

(See the "Nonstop Forwarding Enhanced FIB Refresh (Cisco IOS 12.2(8)T)" section on page 3 for an explanation of the term "epoch.")

Tasks for configuring epochs for Cisco Express Forwarding tables were introduced with the Nonstop Forwarding Enhanced FIB Refresh feature in Cisco IOS Release 12.2(8)T.

For links to information about other Cisco Express Forwarding and distributed Cisco Express Forwarding features you can configure, refer to the "Additional References" section on page 10.

Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding

Cisco Express Forwarding is enabled by default on most Cisco platforms running Cisco IOS software Release 12.0 or later. When Cisco Express Forwarding is enabled on a router, the Route Processor (RP) performs the express forwarding.

To find out if Cisco Express Forwarding is enabled on your platform, enter the **show ip cef** command. If Cisco Express Forwarding is enabled, you receive output that looks like this:

```
Router# show ip cef

Prefix              Next Hop            Interface
```

```
[...]
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
                    192.168.101.1       FastEthernet6/1
[...]
```

If Cisco Express Forwarding is not enabled on your platform, the output for the **show ip cef** command looks like this:

```
Router# show ip cef

%CEF not running
```

Distributed Cisco Express Forwarding is enabled by default on the Catalyst 6500 series switch, the Cisco 7500 series router, and the Cisco 12000 Series Internet Router. When Distributed Cisco Express Forwardingis enabled on your platform, the line cards perform the express forwarding.

If Cisco Express Forwarding is not enabled on your platform, use the **ip cef** command to enable (central) Cisco Express Forwarding or the **ip cef distributed** command to enable Distributed Cisco Express Forwarding.

Nonstop Forwarding Enhanced FIB Refresh (Cisco IOS 12.2(8)T)

Networks must be configured to minimize traffic disruption and offer the most uptime possible. The Nonstop Forwarding (NSF) Enhanced FIB Refresh feature enables users to continue forwarding IP traffic while Cisco Express Forwarding database tables are being rebuilt. IP forwarding on the router is therefore uninterrupted.

NSF Enhanced FIB Refresh provides for the continuation of Cisco Express Forwarding forwarding by tracking epochs. The term “epoch” refers to a period of time. A new epoch for a Cisco Express Forwarding table begins when a table rebuild is initiated. The time after this instant is in an epoch different from the time before, and the different epochs are numbered between 0 and 255. Through the use of epochs, the software can distinguish between old and new forwarding information in the same database structure and can retain the old Cisco Express Forwarding database table while the software builds a new table. This is called epoch tracking and it allows Cisco Express Forwarding forwarding to continue uninterrupted while new Cisco Express Forwarding tables are being constructed, and it makes possible a seamless switchover when the new table becomes active.

Epoch Numbering for Cisco Express Forwarding FIB and Adjacency Tables

A new epoch for a Cisco Express Forwarding table begins when a table rebuild is initiated. The time after this instant is in an epoch different from the time before. The first epoch is numbered 0, and it begins when the Cisco Express Forwarding table is created. The epoch number increases by 1 for each new revision of the Cisco Express Forwarding table until the epoch number reaches 255. The next epoch after 255 is 0. A new epoch cannot begin if any table entries remain from the last time the epoch number was used. The epoch number for a given table is the same for each instance of the table (for example, on each RP and on each line card where distributed Cisco Express Forwarding is active).

Each entry added to a FIB table or the adjacency table has a new field that records the current epoch for that table at the time the entry was added. When an entry is modified, the epoch of the entry is updated to record the table's current epoch. A record is kept of how many entries exist from each epoch. The epoch number cannot be incremented if any existing entries have the same epoch number as the next epoch value.

When the routing protocols signal that they have converged, all FIB and adjacency entries that have epoch numbers older than the current epoch number are removed from the FIB and adjacency tables.

When you need a Cisco Express Forwarding table to be rebuilt, the epoch number for that table is incremented, and the table is rebuilt in place. When rebuilding is complete, "stale" entries are removed from the table. You can increment the epoch of a single table or multiple tables at the same time when you enter the **clear ip cef epoch** [**all-vrfs** | **full** | **vrf** [*table*]] command. See the "When to Refresh the Cisco Express Forwarding or Adjacency Tables" section on page 4 for information on when you might need to rebuild a Cisco Express Forwarding table.

When you display information from a Cisco Express Forwarding table (for example, with the **show ip cef epoch** command), the table epoch is shown in the summary table. When detailed information is displayed for each table entry, the epoch number of each entry is shown.

Epoch Synchronization Between the RP and Line Cards

When FIB or adjacency entries are distributed from the central tables on the RP, the updates contain the epoch of the entry, ensuring that the distinction between old and new entries is maintained in distributed systems.

When a table is initialized on a line card, the current epoch of the table on the RP is sent to the line card. When the epoch is incremented on the RP, an event indicating that a new epoch has begun is sent to each line card.

Epoch Numbering for Routers That Support High Availability

In a router that supports high availability (HA), the epoch numbers for all Cisco Express Forwarding tables are incremented when an RP transitions from standby mode to active. After switchover, the active secondary RP initially has FIB and adjacency databases that are the same as those of the primary RP. When the epoch number for each table is incremented, all existing entries are considered stale. However, forwarding continues as normal. As the routing protocols start to repopulate the FIB and adjacency databases, existing and new entries receive the new epoch number, indicating that the entries have been refreshed.

When to Refresh the Cisco Express Forwarding or Adjacency Tables

You refresh or rebuild the Cisco Express Forwarding or adjacency tables when the tables contain inconsistencies.

Cisco 7500 series and Cisco 12000 Series Internet routers supportdistributed Cisco Express Forwarding, in which line cards make forwarding decisions based on stored copies of the same FIB and adjacency tables that are found on the RP. The tables on the line cards and the RP must remain synchronized.

Inconsistencies occur when forwarding information (a prefix) is missing on a line card, or the next-hop IP address on the line card is not the same as the next-hop IP address on the RP. Because updates to the RP and line card databases are not synchronous, fleeting inconsistencies can result.

Cisco Express Forwarding consistency checkers detect when forwarding information on the line cards and the RP lose synchronization. For more information on consistency checkers, see the "Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards" module.

How to Configure Epochs and Verify Epoch Information for Cisco Express Forwarding Tables

This section contains instructions on how to configure epochs for Cisco Express Forwarding tables. Perform the following tasks to begin new epochs and increment the epoch number of the adjacency and Cisco Express Forwarding tables:

- Beginning a New Epoch and Incrementing the Epoch Number of the Adjacency Table, page 5 (optional)
- Beginning a New Epoch and Incrementing the Epoch Number of One or All Cisco Express Forwarding Tables, page 6 (optional)
- Verifying Epoch Information for Cisco Express Forwarding and Adjacency Tables, page 7 (optional)

Beginning a New Epoch and Incrementing the Epoch Number of the Adjacency Table

Perform the following task to begin a new epoch and increment the epoch number of the adjacency table.

Use this task when you need to rebuild the adjacency table. A new adjacency table might be required because you need to remove inconsistencies from the table.

SUMMARY STEPS

1. **enable**
2. **show ip cef epoch**
3. **clear adjacency table**
4. **show ip cef epoch**
5. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show ip cef epoch** **Example:** `Router# show ip cef epoch`	Displays entries in the forwarding information base (FIB) or displays a summary of the FIB. • The **epoch** keyword displays the table epochs of the adjacency table and all FIB tables.
Step 3	**clear adjacency table** **Example:** `Router# clear adjacency table`	Begins a new epoch and increments the epoch number of the adjacency table.

	Command or Action	Purpose
Step 4	**show ip cef epoch** **Example:** `Router# show ip cef epoch`	Displays entries in the FIB or displays a summary of the FIB. • The **epoch** keyword displays the table epochs of the adjacency table and all FIB tables.
Step 5	**exit** **Example:** `Router# exit`	Exits to user EXEC mode.

Beginning a New Epoch and Incrementing the Epoch Number of One or All Cisco Express Forwarding Tables

Perform the following task to begin a new epoch and increment the epoch number of one or all of the Cisco Express Forwarding tables.

Use the **clear ip cef epoch** command when you want to rebuild a Cisco Express Forwarding table. This command increments the epoch and flushes entries associated with the old epoch. This command also clears any inconsistencies that might exist between Cisco Express Forwarding tables on the PR and Cisco Express Forwarding tables on the line cards. If everything in the system is working correctly, the command has no effect on the Cisco Express Forwarding forwarding tables, other than changing the current epoch values.

SUMMARY STEPS

1. **enable**
2. **show ip cef epoch**]
3. **clear ip cef epoch** [**all-vrfs** | **full** | **vrf** [*table*]]
4. **show ip cef epoch**
5. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show ip cef epoch** **Example:** `Router# show ip cef epoch`	Displays entries in the FIB or displays a summary of the FIB. • The **epoch** keyword displays the table epochs of the adjacency table and all FIB tables.

	Command or Action	Purpose
Step 3	**clear ip cef epoch** [**all-vrfs** | **full** | **vrf** [*table*]] **Example:** `Router# clear ip cef epoch full`	Begins a new epoch and increments the epoch number of one or all Cisco Express Forwarding tables. • The **all-vrfs** keyword begins a new epoch for all FIB tables. • The **full** keyword begins a new epoch for all tables, including adjacency tables. • The **vrf** keyword begins a new epoch for the specified FIB table. • The *table* argument is the name of a specific Virtual Private Network (VPN) routing and forwarding instance (VRF).
Step 4	**show ip cef epoch** **Example:** `Router# show ip cef epoch`	Displays entries in the FIB or displays a summary of the FIB. • The **epoch** keyword displays the epochs of the adjacency table and all FIB tables.
Step 5	**exit** **Example:** `Router# exit`	Exits to user EXEC mode.

Verifying Epoch Information for Cisco Express Forwarding and Adjacency Tables

Perform the following task to verify epoch information for Cisco Express Forwarding and adjacency tables.

SUMMARY STEPS

1. **enable**
2. **show adjacency detail**
3. **show adjacency summary**
4. **show ip cef epoch**
5. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. For example:

```
Router> enable
```

Enter your password if prompted.

Step 2 **show adjacency summary detail**

Use this command to verify that the epoch number is displayed for each entry in the adjacency table as you expect. For example:

```
Router# show adjacency detail

Protocol Interface                 Address
IP       Serial5/0/0/1:1           point2point(7)
                                   0 packets, 0 bytes
                                   0F000800
                                   CEF   expires: 00:02:09
                                         refresh: 00:00:09
                                   Epoch: 14
IP       Serial5/0/1/1:1           point2point(7)
                                   0 packets, 0 bytes
                                   0F000800
                                   CEF   expires: 00:02:09
                                         refresh: 00:00:09
                                   Epoch: 14
```

The epoch number is displayed for each entry in the adjacency table. In this example, the epoch number of each entry is 14.

Step 3 show adjacency summary

Use this command to verify that the epoch number for each adjacency in the adjacency table is as you expect. For example:

```
Router# show adjacency summary

Adjacency Table has 2 adjacencies
  Table epoch: 14 (2 entries at this epoch)

  Interface                Adjacency Count
Serial5/0/0/1:1           1
Serial5/0/1/1:1           1
```

Use the epoch information in the summary section to verify that the epoch number for each adjacency in the adjacency table is as expected. The epoch number is 14 in this example, the same as the epoch number displayed in the **show adjacency detail** command in the previous step.

Step 4 show ip cef epoch

Use this command to verify that Cisco Express Forwarding information in all FIB tables, including the adjacency table, is as you expect.

In the following example, Cisco Express Forwarding epoch information is verified for all FIB tables, including the adjacency table:

```
Router# show ip cef epoch

CEF epoch information:

Table: Default-table
  Table epoch: 77 (19 entries at this epoch)

Adjacency table
  Table epoch: 16 (2 entries at this epoch)
```

Step 5 exit

Use this command to exit to user EXEC mode. For example:

```
Router# exit
Router>
```

Configuration Examples for Configuring Basic Cisco Express Forwarding

This section contains the following epoch configuration examples:

Beginning a New Epoch and Incrementing the Epoch Number of the Adjacency Table: Example

The following example shows how to begin a new epoch and increment the epoch number of the adjacency table:

```
Router# show ip cef epoch

CEF epoch information:

Table: Default-table
     Table epoch: 2 (43 entries at this epoch)

Adjacency table
     Table epoch: 2 (5 entries at this epoch)

Router# clear adjacency table
```

After clearing:

```
Router# show ip cef epoch

CEF epoch information:

Table: Default-table
     Table epoch: 3 (43 entries at this epoch)

Adjacency table
     Table epoch: 3 (5 entries at this epoch)
```

Beginning a New Epoch and Incrementing the Epoch Number of One or All Cisco Express Forwarding Tables: Examples

The following example shows how to begin a new epoch and increment the epoch number of all Cisco Express Forwarding tables:

```
Router# clear ip cef epoch full
```

The following example shows the output before and after you clear the epoch table and increment the epoch number. Before clearing:

```
router# show ip cef epoch

CEF epoch information:

Table: Default-table
     Table epoch: 3 (43 entries at this epoch)

Adjacency table
     Table epoch: 3 (5 entries at this epoch)
```

After clearing:

```
router# clear ip cef epoch full

router# show ip cef epoch

CEF epoch information:

Table: Default-table
     Table epoch: 4 (43 entries at this epoch)

Adjacency table
     Table epoch: 4 (5 entries at this epoch)
```

Additional References

The following sections provide references related to configuring epochs for Cisco Express Forwarding tables.

Related Documents

Related Topic	Document Title
List of the features documented in the Cisco Express Forwarding modules	*Cisco Express Forwarding Features Roadmap*
Overview of the Cisco Express Forwarding feature	*Cisco Express Forwarding Overview*
Tasks for verifying basic Cisco Express Forwarding and distributed Cisco Express Forwarding operation	*Configuring Basic Cisco Express Forwarding for Improved Performance, Scalability, and Resiliency in Dynamic Networks*
Tasks for enabling or disabling Cisco Express Forwarding or distributed Cisco Express Forwarding	*Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding to Customize Switching and Forwarding for Dynamic Networks*
Tasks for configuring a load-balancing scheme for Cisco Express Forwarding	*Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic*
Tasks for configuring Cisco Express Forwarding consistency checkers	*Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards*
Tasks for configuring and verifying Cisco Express Forwarding network accounting	*Configuring Cisco Express Forwarding Network Accounting*
Tasks for customizing the display of recorded Cisco Express Forwarding events	*Customizing the Display of Recorded Cisco Express Forwarding Events*

Related Topic	Document Title
Troubleshooting tips for incomplete adjacencies	*Troubleshooting Incomplete Adjacencies with CEF*
Description and use of the Cisco Express Forwarding consistency checkers available for the Cisco 7500 and 12000 series routers	*Troubleshooting Prefix Inconsistencies with Cisco Express Forwarding*
Explanation of and troubleshooting information for the Cisco IOS software implementation of Layer 3 load balancing across multiple parallel links when Cisco Express Forwarding is used	*Troubleshooting Load Balancing Over Parallel Links Using Cisco Express Forwarding*
Causes of common Cisco Express Forwarding-related error messages on platforms running distributed Cisco Express Forwarding switching (Cisco 7500 series routers and Cisco 12000 Series Internet routers) and how to troubleshoot them	*Troubleshooting Cisco Express Forwarding-Related Error Messages*
Troubleshooting unicast IP routing on Catalyst 6500/6000 switches with Supervisor Engine 2, Policy Feature Card 2 (PFC2), or Multilayer Switch Feature Card 2 (MSFC2)	*Troubleshoot Unicast IP Routing Involving CEF on Catalyst 6500/6000 Series Switches with a Supervisor Engine 2 and Running CatOS System Software*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Feature Information for Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables

Table 1 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Release 12.2(1) or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the *Cisco Express Forwarding Features Roadmap*.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 1 Feature Information for Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables

Feature Name	Releases	Feature Configuration Information
Nonstop Forwarding Enhanced FIB Refresh	12.2(8)T	This feature allows you to clear the forwarding table on demand and to continue forwarding through the use of the old entries in the table while the new forwarding table is being built. The following sections provide information about this feature: • Nonstop Forwarding Enhanced FIB Refresh (Cisco IOS 12.2(8)T), page 3 • Epoch Numbering for Cisco Express Forwarding FIB and Adjacency Tables, page 3 • Epoch Synchronization Between the RP and Line Cards, page 4 • Epoch Numbering for Routers That Support High Availability, page 4 • When to Refresh the Cisco Express Forwarding or Adjacency Tables, page 4 • Beginning a New Epoch and Incrementing the Epoch Number of the Adjacency Table, page 5 • Beginning a New Epoch and Incrementing the Epoch Number of One or All Cisco Express Forwarding Tables, page 6 • Verifying Epoch Information for Cisco Express Forwarding and Adjacency Tables, page 7

Glossary

adjacency—A relationship formed between selected neighboring routers and end nodes for the purpose of exchanging routing information. Adjacency is based upon the use of a common media segment by the routers and nodes involved.

Cisco Express Forwarding—A Layer 3 switching technology. Cisco Express Forwarding can also refer to central Cisco Express Forwarding mode, one of two modes of Cisco Express Forwarding operation. Cisco Express Forwarding enables a Route Processor to perform express forwarding. Distributed Cisco Express Forwarding is the other mode of Cisco Express Forwarding operation.

distributed Cisco Express Forwarding—A mode of Cisco Express Forwarding operation in which line cards (such as Versatile Interface Processor (VIP) line cards) maintain identical copies of the forwarding information base (FIB) and adjacency tables. The line cards perform the express forwarding between port adapters; this relieves the Route Switch Processor of involvement in the switching operation.

FIB—forwarding information base. A component of Cisco Express Forwarding that is conceptually similar to a routing table or information base. The router uses the FIB lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The router maintains a mirror image of the forwarding information in an IP routing table.

LIB—label information base. A database used by a label switch router (LSR) to store labels learned from other LSRs, as well as labels assigned by the local LSR.

line card—A general term for an interface processor that can be used in various Cisco products. For example, a Versatile Interface Processor (VIP) is a line card for the Cisco 7500 series router.

prefix—The network address portion of an IP address. A prefix is specified by a network and mask and is generally represented in the format network/mask. The mask indicates which bits are the network bits. For example, 1.0.0.0/16 means that the first 16 bits of the IP address are masked, making them the network bits. The remaining bits are the host bits. In this example, the network number is 10.0.

RIB—Routing Information Base. A central repository of routes that contains Layer 3 reachability information and destination IP addresses or prefixes. The RIB is also known as the routing table.

RP—Route Processor. The processor module in the Cisco 7000 series routers that contains the CPU, system software, and most of the memory components that are used in the router. It is sometimes called a supervisory processor.

RSP—Route Switch Processor. The processor module used in the Cisco 7500 series routers that integrates the functions of the Route Processor (RP) and the Switch Processor (SP).

SP—Switch Processor. Cisco 7000-series processor module that acts as the administrator for all CxBus activities. Sometimes called CiscoBus controller.

Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards

First Published: May 2, 2005
Last Updated: February 11, 2008

This module contains information about and instructions for configuring Cisco Express Forwarding (consistency checkers. Cisco Express Forwarding consistency checkers help you find any database inconsistencies, such as an IP prefix missing from a line card or a Route Processor (RP). You can investigate and resolve the inconsistency by examining the associated Cisco Express Forwarding system error messages that occur and by issuing Cisco Express Forwarding **debug** and **show** commands.

Cisco Express Forwarding is an advanced Layer 3 IP switching technology. It optimizes network performance and scalability for all kinds of networks: those that carry small amounts of traffic and those that carry large amounts of traffic in complex patterns, such as the Internet and networks characterized by intensive web-based applications or interactive sessions.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Configuring Basic Cisco Express Forwarding" section on page 10.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

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Prerequisites for Configuring Basic Cisco Express Forwarding

Cisco Express Forwarding must be up and running on the networking device before you can configure Cisco Express Forwarding consistency checkers.

Restrictions for Configuring Basic Cisco Express Forwarding

The Cisco Express Forwarding consistency checkers lc-detect and scan-lc apply only to devices that have distributed Cisco Express Forwarding enabled.

Information About Configuring Basic Cisco Express Forwarding

Before configuring Cisco Express Forwarding consistency checkers, you should understand the following:

- Cisco Platform Support for Cisco Express Forwarding and Distributed Cisco Express Forwarding, page 2
- Cisco Express Forwarding Consistency Checker Types for Cisco Express Forwarding and Distributed Cisco Express Forwarding, page 3

For links to information about other Cisco Express Forwarding and distributed Cisco Express Forwarding features that you can configure, refer to the following section:

- How to Configure Cisco Express Forwarding Consistency Checkers, page 4

Cisco Platform Support for Cisco Express Forwarding and Distributed Cisco Express Forwarding

Cisco Express Forwarding is enabled by default on most Cisco platforms running Cisco IOS software Release12.0 or later. When Cisco Express Forwarding is enabled on a router, the RP performs the express forwarding.

To find out if Cisco Express Forwarding is enabled on your platform, enter the **show ip cef** command. If Cisco Express Forwarding is enabled, you receive output that looks like this:

```
Router# show ip cef

Prefix              Next Hop            Interface
[...]
```

```
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
                    192.168.101.1       FastEthernet6/1
[...]
```

If Cisco Express Forwarding is not enabled on your platform, the output for the **show ip cef** command looks like this:

```
Router# show ip cef

%CEF not running
```

Distributed Cisco Express Forwarding is enabled by default on the Catalyst 6500 series switch, the Cisco 7500 series router, and the Cisco 12000 Series Internet Router. When distributed Cisco Express Forwarding is enabled on your platform, the line cards perform the express forwarding.

If Cisco Express Forwarding is not enabled on your platform, use the **ip cef** command to enable Cisco Express Forwarding or the **ip cef distributed** command to enable distributed Cisco Express Forwarding.

Cisco Express Forwarding Consistency Checker Types for Cisco Express Forwarding and Distributed Cisco Express Forwarding

Cisco Express Forwarding uses routing information that is retrieved from the Routing Information Base (RIB), the RP, and the line card databases to perform express forwarding. As these databases are updated, inconsistencies might result, due to the asynchronous nature of the distribution mechanism for these databases. Inconsistencies caused by asynchronous database distribution are of the following types:

- Missing information, such as a particular prefix, on a line card
- Different information, such as different next hop IP addresses, on the line card

Cisco Express Forwarding supports passive and active consistency checkers that run independently to uncover these forwarding inconsistencies. Table 1 describes the consistency checkers and indicates whether the checker operates on the RP or the line card.

Table 1 Types of Cisco Express Forwarding Consistency Checkers

Checker Type	Operates On	Description
Lc-detect	Line card	(Distributed Cisco Express Forwarding only) Retrieves IP prefixes found missing from the line card FIB table. If IP prefixes are missing, the line card cannot forward packets for the corresponding addresses. Lc-detect then sends IP prefixes to the RP for confirmation. If the RP finds that it has the relevant entry, an inconsistency is detected, and an error message is displayed. Also, the RP sends a signal back to the line card confirming that the IP prefix contributes to the creation of an inconsistency.
Scan-lc	Line card	(Distributed Cisco Express Forwarding only) Looks through the FIB table for a configurable time period and sends the next *n* prefixes to the RP. The RP does an exact lookup in its FIB table. If the RP finds that the prefix is missing, the RP reports an inconsistency. The RP sends a signal back to the line card for confirmation. The time period and number of prefixes sent are configured with the **ip cef table consistency-check** command.

Table 1 Types of Cisco Express Forwarding Consistency Checkers (continued)

Checker Type	Operates On	Description
Scan-rp	Route Processor	Looks through the RP FIB table for a configurable time period and sends the next *n* prefixes to the line card. (This action is opposite to the one that the scan-lc checker performs.) The line card does an exact lookup in the FIB table. If the line card finds the prefix missing, the line card reports an inconsistency and signals the RP for confirmation. The time period and number of prefixes sent are configured with the **ip cef table consistency-check** command.
Scan-rib	Route Processor	Operates on all (even nondistributed) RPs, and scans the RIB to ensure that prefix entries are present in the RP FIB table.

Cisco Express Forwarding consistency checkers are enabled by default for Cisco IOS Releases 12.0(20)S and later. Console errors are disabled by default.

If you find a database inconsistency, such as an IP prefix missing from a line card or an RP, you can investigate and resolve it by examining the Cisco Express Forwarding system error messages and by issuing Cisco Express Forwarding **debug** and **show** commands.

For Cisco Express Forwarding consistency checker system error messages, refer to the *12.3 T System Message Guide*.

How to Configure Cisco Express Forwarding Consistency Checkers

Perform the following tasks to configure Cisco Express Forwarding consistency checkers:

- Enabling Cisco Express Forwarding Consistency Checkers, page 4 (optional)
- Displaying and Clearing Cisco Express Forwarding Table Inconsistencies, page 5 (optional)

Enabling Cisco Express Forwarding Consistency Checkers

Perform the following task to enable Cisco Express Forwarding consistency checkers.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef table consistency-check** [**type** {**lc-detect** | **scan-lc** | **scan-rib** | **scan-rp**}] [**count** *count-number*] [**period** *seconds*]
4. **ip cef table consistency-check** [**settle-time** *seconds*]
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip cef table consistency-check** [**type** {**lc-detect** | **scan-lc** | **scan-rib** | **scan-rp**}] [**count** *count-number*] [**period** *seconds*] **Example:** `Router(config)# ip cef table consistency-check scan-rib count 100 period 60`	Enables Cisco Express Forwarding table consistency checker types and parameters. • The **type** keyword indicates the type of consistency check to enable. • The **lc-detect** keyword enables the line card to detect a missing prefix, which is confirmed by the RP. • The **scan-lc** keyword enables a passive scan check of tables on the line card. • The **scan-rib** keyword enables a passive scan check of tables on the RP and a comparison with the RIB. • The **scan-rp** keyword enables a passive scan check of tables on the RP. • The **count**-*number* keyword-argument pair is the maximum number of prefixes to check per scan. The range is from 1 to 225. • The **period** *seconds* keyword-argument pair is the time during which updates for a candidate prefix are ignored as inconsistencies. The range is from 1 to 3600 seconds.
Step 4	**ip cef table consistency-check** [**settle-time** *seconds*] **Example:** `Router(config)# ip cef table consistency-check settle-time 65`	Suppresses inconsistency errors during route updates. • The **settle-time** *seconds* keyword-argument pair is the time elapsed during which updates for a candidate prefix are ignored as inconsistencies. The range is from 1 to 3600 seconds.
Step 5	**end** **Example:** `Router(config)# end`	Exits to privileged EXEC mode.

Displaying and Clearing Cisco Express Forwarding Table Inconsistencies

Perform the following task to display and clear Cisco Express Forwarding table inconsistency records found by the lc-detect, scan-rp, scan-rib, and scan-lc detection mechanisms.

SUMMARY STEPS

1. **enable**
2. **show ip cef inconsistency**
3. **clear ip cef inconsistency**
4. **clear cef linecard** [*slot-number*] [**adjacency | interface | prefix**]
5. **show ip cef inconsistency**
6. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. For example:

```
Router> enable
```

Enter your password if prompted.

Step 2 **show ip cef inconsistency**

Use this command to display Cisco Express Forwarding IP inconsistencies. For example:

```
Router# show ip cef inconsistency

Table consistency checkers (settle time 65s)
 lc-detect:running
 0/0/0 queries sent/ignored/received
 scan-lc:running [100 prefixes checked every 60s]
 0/0/0 queries sent/ignored/received
 scan-rp:running [100 prefixes checked every 60s]
 0/0/0 queries sent/ignored/received
 scan-rib:running [100 prefixes checked every 60s]
 0/0/0 queries sent/ignored/received
Inconsistencies:0 confirmed, 0/16 recorded
```

For each checker type, the output shows the number of prefixes that Cisco Express Forwarding must check and the number of seconds (the settle time) during which an inconsistency between RP and line card tables is ignored. The preceding output shows that 0 inconsistencies existed between these tables at the time the command was entered on the router.

Step 3 **clear ip cef inconsistency**

Use this command to clear the Cisco Express Forwarding inconsistency statistics and records found by the Cisco Express Forwarding consistency checkers. For example:

```
Router# clear ip cef inconsistency
```

Step 4 **clear cef linecard** [*slot-number*] [**adjacency | interface | prefix**]

Use this command to clear Cisco Express Forwarding information from line cards. For example:

```
Router# clear cef linecard
```

Step 5 **show ip cef inconsistency**

Use this command to verify that Cisco Express Forwarding statistics on inconsistencies are removed from the RP and the line cards. For example:

```
Router# show ip cef inconsistency
```

```
Table consistency checkers (settle time 65s)
 lc-detect:running
  0/0/0 queries sent/ignored/received
 scan-lc:running [100 prefixes checked every 60s]
  0/0/0 queries sent/ignored/received
 scan-rp:running [100 prefixes checked every 60s]
  0/0/0 queries sent/ignored/received
 scan-rib:running [1000 prefixes checked every 60s]
  0/0/0 queries sent/ignored/received
Inconsistencies:0 confirmed, 0/16 recorded
```

This sample output shows that four consistency checkers are enabled, that each checker sends 100 prefixes to be checked every 60 seconds, and that the time during which inconsistencies are ignored is 65 seconds. In this example, no inconsistencies were found.

Step 6 **exit**

Use this command to exit to user EXEC mode. For example:

```
Router# exit
Router>
```

Configuration Examples for Configuring Basic Cisco Express Forwarding

This section contains the following Cisco Express Forwarding consistency checker configuration example:

- Enabling Cisco Express Forwarding Consistency Checkers: Example, page 7

Enabling Cisco Express Forwarding Consistency Checkers: Example

The following example shows how to enable the scan-rp Cisco Express Forwarding consistency checker.

```
configure terminal
!
ip cef table consistency-check scan-rp count 225 period 3600
ip cef table consistency-check settle-time 2500
end
```

The RP is configured to send 3600 prefixes to the line cards every 225 seconds. After the prefixes are sent, the line cards is to wait 2500 seconds before signaling the PR to report an inconsistency (if there is one).

Additional References

The following sections provide references related to configuring Cisco Express Forwarding consistency checkers.

Related Documents

Related Topic	Document Title
Troubleshooting tips for incomplete adjacencies	*Troubleshooting Incomplete Adjacencies with CEF*
Description of and troubleshooting information for the consistency checker available for the Cisco 7500 series and Cisco 12000 Series Internet routers	*Troubleshooting Prefix Inconsistencies with Cisco Express Forwarding*
List of the features documented in the Cisco Express Forwarding modules	*Cisco Express Forwarding Features Roadmap*
Overview of the Cisco Express Forwarding feature	*Cisco Express Forwarding Overview*
Tasks for verifying basic Cisco Express Forwarding and distributed Cisco Express Forwarding operation	*Configuring Basic Cisco Express Forwarding for Improved Performance, Scalability, and Resiliency in Dynamic Networks*
Tasks for enabling or disabling Cisco Express Forwarding or distributed Cisco Express Forwarding	*Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding to Customize Switching and Forwarding for Dynamic Networks"*
Tasks for configuring a load-balancing scheme for Cisco Express Forwarding	*Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic*
Tasks for configuring epochs for Cisco Express Forwarding tables	*Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables*
Tasks for configuring and verifying Cisco Express Forwarding network accounting	*Configuring Cisco Express Forwarding Network Accounting*
Tasks for customizing the display of recorded Cisco Express Forwarding events	*Customizing the Display of Recorded Cisco Express Forwarding Events*
Causes of common Cisco Express Forwarding-related error messages on platforms running distributed Cisco Express Forwarding switching (Cisco 7500 series routers and Cisco 12000 Series Internet routers) and how to troubleshoot them	*Troubleshooting Cisco Express Forwarding-Related Error Messages*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Feature Information for Configuring Basic Cisco Express Forwarding

Table 2 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Release 12.2(1) or 12.0(3)S or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the *Cisco Express Forwarding Features Roadmap*.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 2 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 2 Feature Information for Configuring Basic Cisco Express Forwarding

Feature Name	Releases	Feature Configuration Information
This table is intentionally left blank because no features were introduced or modified in Cisco IOS Release 12.2(1) or later. This table will be updated when feature information is added to this module.	—	—

Glossary

adjacency—A relationship formed between selected neighboring routers and end nodes for the purpose of exchanging routing information. Adjacency is based upon the use of a common media segment by the routers and nodes involved.

Cisco Express Forwarding—A Layer 3 switching technology. Cisco Express Forwarding can also refer to central Cisco Express Forwarding mode, one of two modes of Cisco Express Forwarding operation. Cisco Express Forwarding enables a Route Processor to perform express forwarding. Distributed Cisco Express Forwarding is the other mode of Cisco Express Forwarding operation.

distributed Cisco Express Forwarding—A mode of Cisco Express Forwarding switching in which line cards (such as Versatile Interface Processor (VIP) line cards) maintain identical copies of the forwarding information base (FIB) and adjacency tables. The line cards perform the express forwarding between port adapters; this relieves the Route Switch Processor of involvement in the switching operation.

FIB—forwarding information base. A component of Cisco Express Forwarding that is conceptually similar to a routing table or information base. The router uses the FIB lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The router maintains a mirror image of the forwarding information in an IP routing table.

IPC—interprocess communication. The mechanism that enables the distribution of Cisco Express Forwarding tables from the Route Switch Processor (RSP) to the line card when the router is operating in distributed Cisco Express Forwarding mode.

LIB—label information base. A database used by a label switch router (LSR) to store labels learned from other LSRs, as well as labels assigned by the local LSR.

line card—A general term for an interface processor that can be used in various Cisco products. For example, a Versatile Interface Processor (VIP) is a line card for the Cisco 7500 series router.

MPLS—Multiprotocol Label Switching. An emerging industry standard for the forwarding of packets along the normal routing paths (sometimes called MPLS hop-by-hop forwarding).

prefix—The network address portion of an IP address. A prefix is specified by a network and mask and is generally represented in the format network/mask. The mask indicates which bits are the network bits. For example, 1.0.0.0/16 means that the first 16 bits of the IP address are masked, making them the network bits. The remaining bits are the host bits. In this example, the network number is 10.0.

RIB—Routing Information Base. A central repository of routes that contains Layer 3 reachability information and destination IP addresses or prefixes. The RIB is also known as the routing table.

RP—Route Processor. The processor module in the Cisco 7000 series routers that contains the CPU, system software, and most of the memory components that are used in the router. It is sometimes called a supervisory processor.

VPN—Virtual Private Network. The result of a router configuration that enables IP traffic to use tunneling to travel securely over a public TCP/IP network.

VRF—A Virtual Private Network (VPN) routing/forwarding instance. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table. In general, a VRF includes the routing information that defines a customer VPN site that is attached to a PE router.

Configuring Cisco Express Forwarding Network Accounting

First Published: May 2, 2005
Last Updated: February 11, 2008

This module contains information about and instructions for configuring network accounting for Cisco Express Forwarding. Accounting produces the statistics that enable you to better understand Cisco Express Forwarding patterns in your network. For example, you might want to find out the number of packets and bytes switched to a destination or the number of packets switched through a destination.

Cisco Express Forwarding is an advanced Layer 3 IP switching technology. It optimizes network performance and scalability for all kinds of networks: those that carry small amounts of traffic and those that carry large amounts of traffic in complex patterns, such as the Internet and networks characterized by intensive web-based applications or interactive sessions.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Configuring Cisco Express Forwarding Network Accounting" section on page 27.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

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

Prerequisites for Configuring Cisco Express Forwarding Network Accounting

Cisco Express Forwarding must be up and running on the networking device before you can configure network accounting for Cisco Express Forwarding. See the "Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding" section for information on how to determine if Cisco Express Forwarding is enabled on your networking device.

Information About Configuring Cisco Express Forwarding Network Accounting

Before you configure Cisco Express Forwarding network accounting, you should understand the following information:

For links to information about other Cisco Express Forwarding and distributed Cisco Express Forwarding features that you can configure, go to the "Additional References" section on page 24.

Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding

Cisco Express Forwarding is enabled by default on most Cisco platforms running Cisco IOS software Release 12.0 or later. When Cisco Express Forwarding is enabled on a router, the Route Processor (RP) performs the express forwarding.

To find out if Cisco Express Forwarding is enabled on your platform, enter the **show ip cef** command. If Cisco Express Forwarding is enabled, you receive output that looks like this:

```
Router# show ip cef

Prefix              Next Hop            Interface
[...]
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
                    192.168.101.1       FastEthernet6/1
[...]
```

If Cisco Express Forwarding is not enabled on your platform, the output for the **show ip cef** command looks like this:

```
Router# show ip cef

%CEF not running
```

Distributed Cisco Express Forwarding is enabled by default on the Catalyst 6500 series switch, the Cisco 7500 series router, and the Cisco 12000 Series Internet Router. When distriobuted Cisco Express Forwarding is enabled on your platform, the line cards perform the express forwarding.

If Cisco Express Forwarding is not enabled on your platform, use the **ip cef** command to enable (central) Cisco Express Forwarding or the **ip cef distributed** command to enable distributed Cisco Express Forwarding.

Central Cisco Express Forwarding or distributed Cisco Express Forwarding has the following restrictions:

- The Cisco 12000 Series Internet routers operate only in distributed Cisco Express Forwarding mode. On these routers, you must not disable distributed Cisco Express Forwarding on an interface.
- If you enable Cisco Express Forwarding and then create an access list that uses the **log** keyword, the packets that match the access list are not Cisco Express Forwarding switched. They are process switched. Logging disables Cisco Express Forwarding.
- Distributed Cisco Express Forwarding switching cannot be configured on the same VIP card on which distributed fast switching is configured.
- Distributed Cisco Express Forwarding is not supported on Cisco 7200 series routers.

See the "Additional References" section on page 24 for links to more information on the features and functionality of Cisco Express Forwarding.

Traffic Matrix Statistics That You Can Collect and View

The traffic matrix statistics (TMS) feature allows an administrator to gather the following data:

- The number of packets and number of bytes that travel across the backbone from internal and external sources. The counts of packets and bytes are called TMS and are useful for determining how much traffic a backbone handles. You can analyze TMS using the following methods:
  - Collecting and viewing TMS through the application of the Network Data Analyzer (NDA)
  - Reading the TMS that reside on the backbone router
- The neighbor autonomous systems of a Border Gateway Protocol (BGP) destination. You can view these systems by reading the tmasinfo_ascii file on the backbone router.

The following sections explain how to collect and view the TMS using the command-line interface (CLI) and the NDA. For detailed instructions on using the NDA, see the *Network Data Analyzer Installation and User Guide*.

TMS and Cisco Express Forwarding Nonrecursive Accounting in Backbone Routers

TMS enables an administrator to capture and analyze data on traffic entering a backbone that is running BGP. The TMS feature also allows an administrator to determine the neighbor autonomous systems of a BGP destination. TMS are counted during packet forwarding by Cisco Express Forwarding nonrecursive accounting.

By enabling a backbone router to gather TMS, you can determine the amount of traffic that enters the backbone from sites outside of the backbone. You can also determine the amount of traffic that is generated within the backbone. This information helps you optimize and manage traffic across the backbone.

The following paragraphs explain how Cisco Express Forwarding nonrecursive accounting aggregates packet statistics for Interior Gateway Protocol (IGP) routes and their dependent BGP routes.

A BGP network deployed by a service provider might have the following components:

- IGP routes that describe the next hop to which traffic should be sent
- BGP routes that specify an intermediate address to which traffic should be sent

The intermediate address specified for the BGP route might be several hops away from the provider edge (PE) router. The next hop for the BGP route is the next hop for the intermediate address of the BGP route. The BGP route is called recursive, because it points through an intermediate address to an IGP route that provides the next hop for forwarding. However, a route lookup results in a next hop that is not directly reachable, as is the case with the BGP route's intermediate address. A recursive lookup to an IGP route is used to decide how to reach the indirect next hop.

Cisco Express Forwarding represents IGP routes as nonrecursive entries and BGP routes as recursive entries that resolve through nonrecursive entries.

Cisco Express Forwarding nonrecursive accounting counts the packets for all of the Cisco Express Forwarding recursive entries (from BGP routes) that resolve through a Cisco Express Forwarding nonrecursive entry and the packets for the nonrecursive entry (from IGP routes). The number of packets is totalled in one location.

The packets forwarded based on a nonrecursive Cisco Express Forwarding entry can be split into two bins based on whether the input interface of the backbone router is configured as internal or external. Thus, all packets that arrive on external interfaces (external to the region of interest) and are forwarded based on a given IGP route (either directly or through a recursive BGP route) are counted together.

The following example shows how Cisco Express Forwarding nonrecursive accounting counts packets when BGP routes resolve to one IGP route and when they do not.

A multiaccess network access point (NAP) has BGP routes referring to hosts on the NAP network.

- If the network is advertised as a single IGP route, all of the BGP routes to the various hosts at that NAP resolve to a single IGP route. Cisco Express Forwarding nonrecursive accounting counts the number of packets sent to all BGP destinations.
- If a network administrator instead advertises individual host routes from the NAP network to the IGP, Cisco Express Forwarding nonrecursive accounting counts packets to those hosts separately.

How Backbone Routers Collect TMS

You can determine the amount of traffic that enters the backbone from sites outside of the backbone if you enable a backbone router to gather TMS. You can also determine the amount of traffic that is generated within the backbone. This information helps you optimize and manage traffic across the backbone. Figure 1 and Figure 2 help illustrate the traffic statistics you can gather using TMS.

Figure 1 shows a sample network with backbone routers and links. The traffic that travels through the backbone is the area of interest for TMS collection. TMS are collected during packet forwarding. The backbone is represented by the darkly shaded routers and bold links. The lighter shaded and unshaded routers are outside the backbone.

Figure 1 Sample Network with Backbone Routers and Links

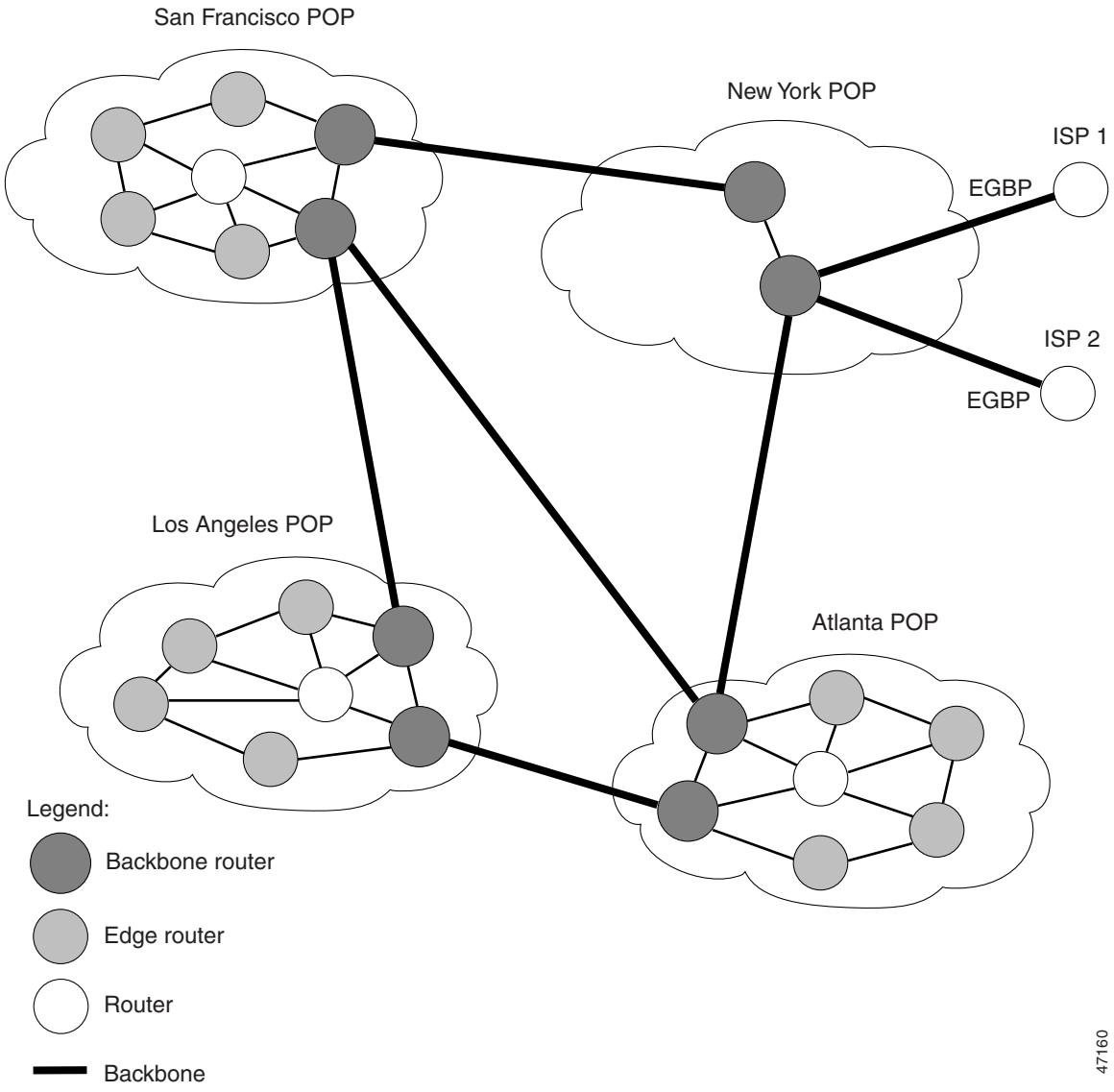
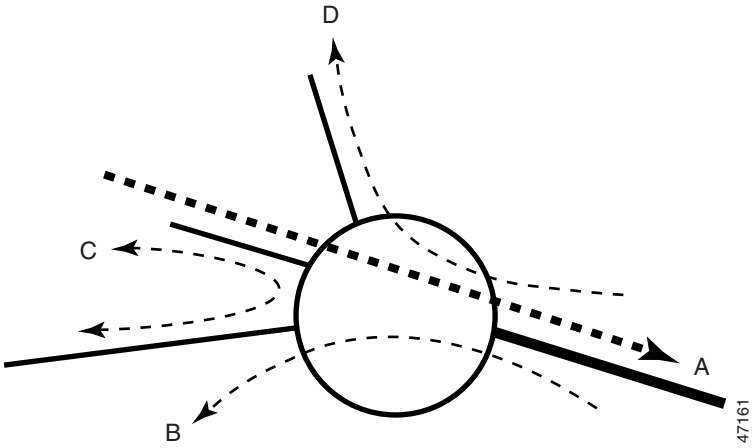


Figure 2 shows an exploded view of the backbone router that links the Los Angeles point of presence (POP) in Figure 1 to the Atlanta POP. The bold line represents the backbone link going to the Atlanta POP.

Figure 2 shows the following types of traffic that travel through the backbone router:

- The dotted line marked A represents traffic entering the backbone from a router that is not part of the backbone. This is called external traffic.
- The dotted lines marked B and D represent traffic that is exiting the backbone. This is called internal traffic.
- The dotted line marked C represents traffic that is not using the backbone and is not of interest to TMS.

Figure 2 Types of Traffic That Travel Through a Backbone Router



You can determine the amount of traffic the backbone handles by enabling a backbone router to track the number of packets and bytes that travel through the backbone router. You can separate the traffic into the categories “internal” and “external.” You separate the traffic by designating incoming interfaces on the backbone router as internal or external.

Once you enable a backbone router to collect TMS, the router starts counters, which dynamically update when network traffic passes through the backbone router. You can retrieve a snapshot of the TMS, either through a command to the backbone router or through the NDA.

External traffic (path A in Figure 2) is the most important for determining the amount of traffic that travels through a backbone router. Internal traffic (paths B and D in Figure 2) is useful for ensuring that you are capturing all of the TMS data. When you receive a snapshot of the TMS, the packets and bytes are displayed in internal and external categories.

TMS Viewing Options

Once TMS are collected, you have three options for viewing the data:

- Viewing the data in a graphical format, using the NDA Display module. The Display module is useful for graphing the traffic matrix data and comparing statistics. See the “TMS Displayed with the NDA Display Module” section on page 7 for more information.

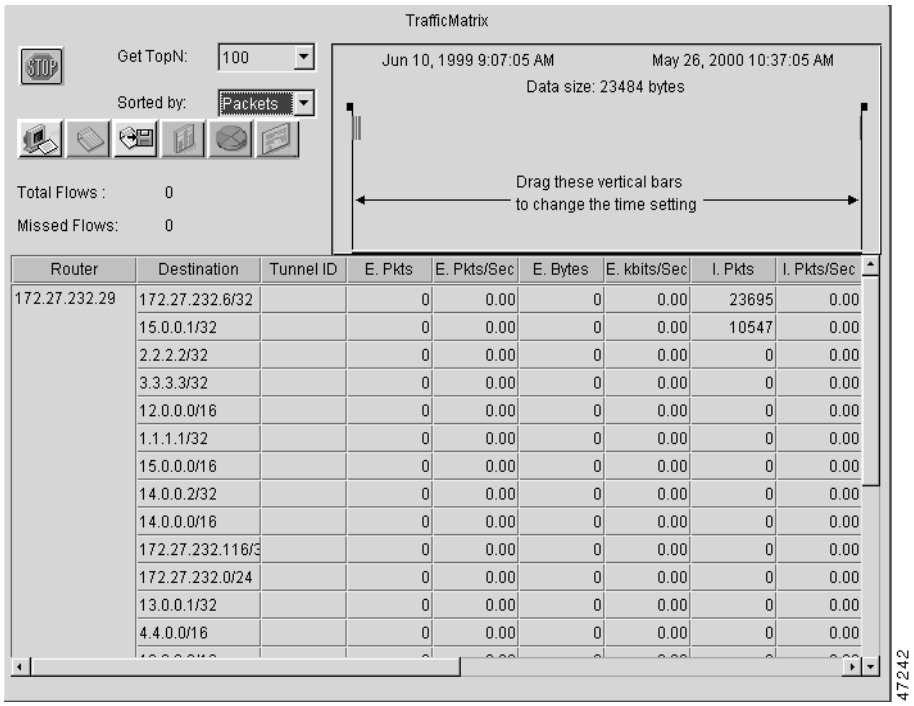
- Entering the **more system:vfiles/tmstats_ascii** command on the backbone router. This command displays a TMS table. See the "Interpreting the Statistics in the tmstats_ascii File" section on page 16 for more information.
- Entering the **show ip cef** command on the backbone router. This command displays nonrecursive accounting data for the backbone router. Included in the output are the numbers of packets and bytes of internal and external traffic that have been collected. See the "Nonrecursive Accounting Information Displayed with the show ip cef Command" section on page 8 for more information.

TMS Displayed with the NDA Display Module

The NDA collects TMS from the backbone router and displays the data through the NDA Display module. The TMS can look similar to the data shown in Figure 3 and Figure 4. The display format depends on the aggregation scheme you select. Refer to the *Network Data Analyzer Installation and User Guide* for more information.

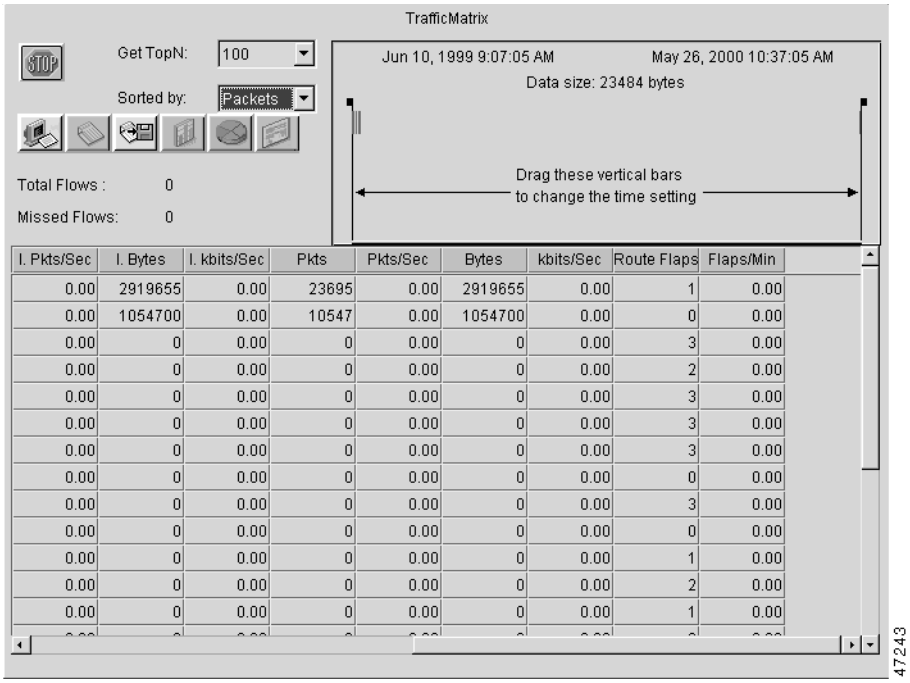
(The view of data that the NDA Display module provides is wide. Slide the scroll bar to the right and left to see all of the data. Figure 3 and Figure 4 taken together show all of the columns of data.)

Figure 3 Displaying TMS Through the NDA (Part 1)



Router	Destination	Tunnel ID	E. Pkts	E. Pkts/Sec	E. Bytes	E. kbits/Sec	I. Pkts	I. Pkts/Sec
172.27.232.29	172.27.232.6/32		0	0.00	0	0.00	23695	0.00
	15.0.0.1/32		0	0.00	0	0.00	10547	0.00
	2.2.2.2/32		0	0.00	0	0.00	0	0.00
	3.3.3.3/32		0	0.00	0	0.00	0	0.00
	12.0.0.0/16		0	0.00	0	0.00	0	0.00
	1.1.1.1/32		0	0.00	0	0.00	0	0.00
	15.0.0.0/16		0	0.00	0	0.00	0	0.00
	14.0.0.2/32		0	0.00	0	0.00	0	0.00
	14.0.0.0/16		0	0.00	0	0.00	0	0.00
	172.27.232.116/3		0	0.00	0	0.00	0	0.00
	172.27.232.0/24		0	0.00	0	0.00	0	0.00
	13.0.0.1/32		0	0.00	0	0.00	0	0.00
	4.4.0.0/16		0	0.00	0	0.00	0	0.00

Figure 4 Displaying TMS Through the NDA (Part 2)



I. Pkts/Sec	I. Bytes	I. kbits/Sec	Pkts	Pkts/Sec	Bytes	kbits/Sec	Route Flaps	Flaps/Min
0.00	2919655	0.00	23695	0.00	2919655	0.00	1	0.00
0.00	1054700	0.00	10547	0.00	1054700	0.00	0	0.00
0.00	0	0.00	0	0.00	0	0.00	3	0.00
0.00	0	0.00	0	0.00	0	0.00	2	0.00
0.00	0	0.00	0	0.00	0	0.00	3	0.00
0.00	0	0.00	0	0.00	0	0.00	3	0.00
0.00	0	0.00	0	0.00	0	0.00	3	0.00
0.00	0	0.00	0	0.00	0	0.00	0	0.00
0.00	0	0.00	0	0.00	0	0.00	3	0.00
0.00	0	0.00	0	0.00	0	0.00	0	0.00
0.00	0	0.00	0	0.00	0	0.00	1	0.00
0.00	0	0.00	0	0.00	0	0.00	2	0.00
0.00	0	0.00	0	0.00	0	0.00	1	0.00

Nonrecursive Accounting Information Displayed with the show ip cef Command

You can use the **show ip cef** command to display nonrecursive accounting information, including the counts of internal and external packets and bytes that have traveled through the IP prefix address/mask (in the format a.b.c.d/len) for an IGP route. Here is an example that shows 0 packets and 0 bytes of external traffic and 1144 packets and 742 bytes of internal traffic for the router with the IP address 10.102.102.102:

```
router# show ip cef 10.102.102.102

10.102.102.10/32, version 34, epoch 0, per-destination sharing
0 packets, 0 bytes
 tag information set
  local tag: 19
 via 10.1.1.100, Ethernet0/0, 0 dependencies
  next hop 10.1.1.100, Ethernet0/0
  valid adjacency
  tag rewrite with Et0/0, 10.1.1.100, tags imposed {17}
 0 packets, 0 bytes switched through the prefix
 tmstats: external 0 packets, 0 bytes
      internal 1144 packets, 742 bytes
 30 second output rate 0 Kbits/sec
```

How to Configure Cisco Express Forwarding Network Accounting

Perform the following tasks to configure Cisco Express Forwarding network accounting:

- Configuring Cisco Express Forwarding Network Accounting, page 9 (required)
- Enabling a Backbone Router to Collect TMS, page 10 (optional)
- Interpreting the Statistics in the tmstats_ascii File, page 16 (optional)
- Viewing Information in the tmasinfo File: BGP Neighbor Autonomous Systems for IGP Destinations, page 19 (optional)
- Verifying Cisco Express Forwarding Network Accounting Information, page 21 (optional)

Configuring Cisco Express Forwarding Network Accounting

Perform the following task to enable network accounting for Cisco Express Forwarding.

When you enable network accounting for Cisco Express Forwarding from the global configuration mode, accounting information is collected on the RP.

When you enable network accounting for distributed Cisco Express Forwarding from the global configuration mode, accounting information grouped by IP prefix (recursive or nonrecursive) is not sent to the RP, but is collected on the line card.

After accounting information is collected for Cisco Express Forwarding or distributed Cisco Express Forwarding, you can display the statistics using the **show ip cef** command. To verify the statistics on a line card, use the **show cef interface statistics** command.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef accounting** {[**non-recursive**] [**per-prefix**] [**prefix-length**]}
4. **exit**

DETAILED STEPS

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

	Command or Action	Purpose
Step 3	**ip cef accounting** {[**non-recursive**] [**per-prefix**] [**prefix-length**]} **Example:** `Router(config)# ip cef accounting per-prefix`	Enables Cisco Express Forwarding network accounting. • The **non-recursive** keyword enables you to count the number of packets and bytes express forwarded through nonrecursive prefixes. This keyword is optional when the command is used in global configuration mode. • The **per-prefix** keyword enables you to count the number of packets and bytes express forwarded to a destination IP address (or prefix). • The **prefix-length** keyword enables accounting based on prefix length.
Step 4	**exit** **Example:** `Router(config)# exit`	Exits to privileged EXEC mode.

Enabling a Backbone Router to Collect TMS

This section contains information about and instructions for enabling a backbone router to collect TMS for Cisco Express Forwarding. Enabling a backbone router to collect TMS requires enabling nonrecursive accounting and setting the interfaces on the router to collect internal or external TMS. The internal and external settings are used only for TMS collection. The interfaces are set to internal by default.

Note Make sure you configure the collection of internal and external TMS on the incoming interface of the backbone router.

You can perform these tasks either through the CLI or through the NDA. The following sections explain each procedure:

- Using the CLI to Enable a Backbone Router to Collect TMS, page 10 (optional)
- Enabling the NDA to Collect TMS on a Backbone Router, page 12 (optional)

Using the CLI to Enable a Backbone Router to Collect TMS

Perform the following task to use the CLI to enable a backbone router to collect TMS.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef**
4. **ip cef accounting** {[**non-recursive** [**per-prefix**] [**prefix-length**]}
5. **interface** *type slot/port* or **interface** *type slot/port-adapter/port*

6. **ip cef accounting non-recursive** {**external** | **internal**}
7. **exit**
8. Repeat Steps 5, 6, and 7 for each incoming interface that you want to configure for TMS.

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip cef** **Example:** `Router(config)# ip cef`	Enables Cisco Express Forwarding on the route processor card.
Step 4	**ip cef accounting** {[**non-recursive** [**per-prefix**] [**prefix-length**]} **Example:** `Router(config)# ip cef accounting non-recursive`	Enables Cisco Express Forwarding network accounting. • The **non-recursive** keyword enables you to count the number of packets and bytes express forwarded through nonrecursive prefixes. This keyword is optional when the command is used in global configuration mode. • The **per-prefix** keyword enables you to count the number of packets and bytes express forwarded to a destination (or prefix). • The **prefix-length** keyword enables accounting based on prefix length.

	Command or Action	Purpose
Step 5	**interface** type slot/port or **interface** type slot/port-adapter/port **Example:** Router(config)# interface ethernet 1/1 or **Example:** Router(config)# interface fastethernet 1/0/0	Configures an interface type and enters interface configuration mode. • The *type* argument specifies the type of interface to be configured. • The *slot*/ argument specifies the slot number. Refer to the appropriate hardware manual for slot and port information. • The *port* argument specifies the port number. Refer to the appropriate hardware manual for slot and port information. • The *port-adapter*/ argument specifies the port adapter number. Refer to the appropriate hardware manual for information about port adapter compatibility. This command specifies the interface on the backbone router that you intend to configure.
Step 6	**ip cef accounting non-recursive** {**external** | **internal**} **Example:** Router(config-if)# ip cef accounting non-recursive external	Enables nonrecursive accounting on the router. • The **external** keyword calls for a count of input traffic data in the nonrecursive external bin. That is, this keyword sets the specified incoming interface so that it can collect data on traffic entering the backbone router from external sources. • The **internal** keyword calls for a count of input traffic data in the nonrecursive internal bin. That is, this keyword sets the specified incoming interface so that it can collect data on internal traffic in the backbone router.
Step 7	**exit** **Example:** Router(config-if)# exit	Exits to privileged EXEC mode.
Step 8	Repeat Steps 5, 6, and 7 for each incoming interface that you want to configure for TMS.	—

Enabling the NDA to Collect TMS on a Backbone Router

Perform the following task to enable the NDA to collect TMS on a backbone router.

You can use the NDA to enable TMS collection and to set the incoming interfaces on the backbone router to collect internal or external traffic data.

SUMMARY STEPS

1. Open the Traffic Matrix Statistics Control window in the NDA.
2. Click the **New** button in the Traffic Matrix Statistics Control window.
3. Specify the new TMS collection parameters, using the Traffic Matrix Statistics Control window.

4. Click **OK** in the New Collection panel.
5. Select the **TMS** tab in the Router Configuration window in the NDA.
6. Set internal and external interfaces on the router.
7. Click **Apply** in the Router Configuration window.

DETAILED STEPS

Step 1 Open the Traffic Matrix Statistics Control window in the NDA.

For specific instructions, refer to the *Network Data Analyzer Installation and User Guide*.

Step 2 Click the **New** button in the Traffic Matrix Statistics Control window.

If a valid directory of router configuration files exists on a designated UtilityServer host in the network, the Traffic Matrix Statistics Control window shown in Figure 5 appears.

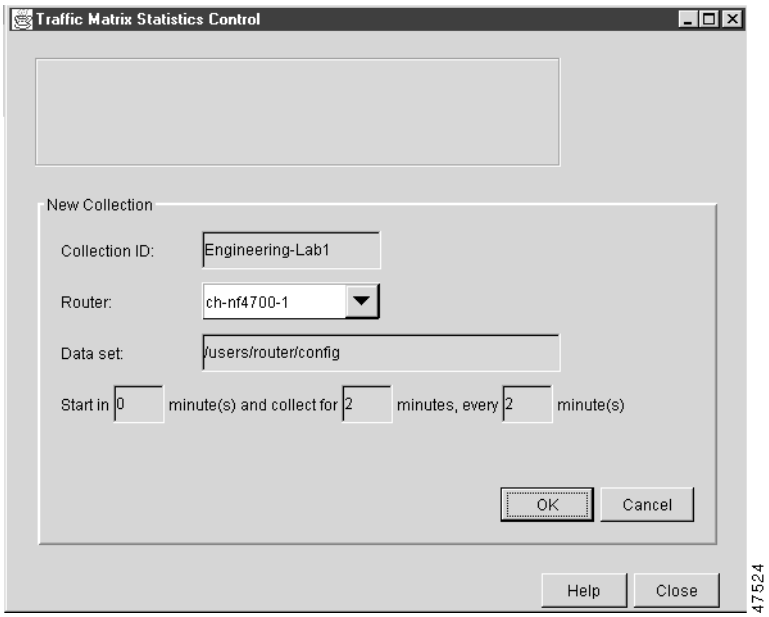
Step 3 Specify the new TMS collection parameters, using the Traffic Matrix Statistics Control window.

The window incorporates a New Collection panel that enables you to define a new TMS collection process. To use the NDA for TMS collection, you must specify the following information:

- The name of the collection (Collection ID)—Enter an alphanumeric name of any length without embedded spaces for the TMS collection process on the selected router (see next bullet).
- The router from which you want to collect TMS—Use the drop-down box to choose the name of a network device where you want to collect TMS.
- How often and how long to collect TMS—Specify each of the following in minutes:
  - How much time is to elapse before the TMS collection process begins (“Start in” field)
  - The overall duration of the TMS collection process (“collect for” field)
  - How often “snapshots” of the traffic counters in the selected router are to be exported to the designated TMS data repository (“every” field)

The window for entering this information on the NDA is similar to the one shown in Figure 5.

Figure 5 Setting the NDA Traffic Matrix Statistics Control Window Collection Parameters



Step 4 Click **OK** in the New Collection panel.

The Traffic Matrix Statistics Control window confirms the information you entered, and the new collection name appears at the top left corner of the window.

Step 5 Select the **TMS** tab in the Router Configuration window in the NDA.

The TMS Router Configuration panel shown in Figure 6 appears. This panel enables you to configure network devices to export TMS data. (For instructions on locating the Router Configuration window, refer to the *Network Data Analyzer Installation and User Guide*.)

Step 6 Set internal and external interfaces on the router.

The Router Configuration window allows you to set the interfaces on the backbone router to collect internal and external packet and byte data. By default, all interfaces are set to collect internal data. Single-selection buttons allow you to associate the interface with either internal data or external data. You can select only one radio button for an interface at one time. Set the interface to collect internal or external data by clicking the appropriate radio button.

The window for selecting this information on the NDA is similar to the one shown in Figure 6.

Figure 6 Setting the NDA Configuration Window

Step 7 Click **Apply** in the Router Configuration window.

Any changes that you have made to the configuration parameters in the TMS Router Configuration panel are applied to the currently selected device. The Apply button affects only changes made in the panel where the button is located.

When the NDA asks if you want to enable Cisco Express Forwarding, click **Yes**.

Interpreting the Statistics in the tmstats_ascii File

This section contains information about and instructions for interpreting the statistics in the timstats_ascii file.

Before you perform the task to interpret the statistics in the tmstats_ascii file, you need to understand the following:

Virtual Files on the Backbone Router

You can read TMS that reside on the backbone router and are stored in the following virtual files:

- tmstats_ascii—TMS in ASCII (human readable) format
- tmstats_binary—TMS in binary (space-efficient) format

The binary file tmstats_binary contains the same information as the ASCII file, except in a space-efficient format. You can copy this file from the router and read it with any utility that accepts files in binary format.

tmstats_ascii File Header Description

The tmstats_ascii file header provides the address of the backbone router and information about how much time the router used to collect and export the TMS data. The header occupies one line and uses the following format:

```
VERSION 1|ADDR<address>|AGGREGATIONTrafficMatrix.ascii|SYSUPTIME<seconds>|
routerUTC<routerUTC>|NTP<synchronized|unsynchronized>|DURATION<aggregateTime>|
```

Table 1 describes the fields in the file header of the tmstats_ascii file.

Table 1 Fields in tmstats_ascii File Header

Maximum Field Length	Field	Description
10	VERSION	File format version
21	ADDR	The IP address of the router
32	AGGREGATION	The type of data being aggregated
21	SYSUPTIME	The time of export (in seconds) since the router booted
21	routerUTC	The time of export (in seconds) since 1900-01-01 (Coordinated Universal Time (UTC)), as determined by the router

Table 1 Fields in tmstats_ascii File Header (continued)

Maximum Field Length	Field	Description
19	NTP	An indication of whether or not the UTC of the router has been synchronized by the Network Time Protocol (NTP) with an authoritative time source, such as a radio clock or an atomic clock attached to a time server
20	DURATION	The time needed to capture the data (in seconds) (trailing |)

Destination Prefix Record Description

The destination prefix record displays the internal and external packets and bytes for the IGP route and uses the following format:

p|*<destPrefix/Mask>*|*<creationSysUpTime>*|*<internalPackets>*|
<internalBytes>|*<externalPackets>*|*<externalBytes>*

The per-prefix records display information only about label switched traffic data. Label forwarding across a backbone router or switch, is based on either dynamic label switching or traffic engineered paths.

What are other record types?

Table 2 describes the fields in the destination prefix record.

Table 2 Destination Prefix Record Fields

Maximum Field Length	Field	Description
2	<*recordType*>	**p** means that the record represents dynamic label switching (for example, LDP) data or headend traffic engineering (TE) tunnel traffic data. **t** means that the record contains TE tunnel midpoint data.
19	destPrefix/Mask	The IP prefix address/mask (in the format a.b.c.d/len) for this IGP route.
11	creationSysUpTime	How long the system had been running when the record was first created.
21	internalPackets	Internal packet count.
21	internalBytes	Internal byte count.
21	externalPackets	External packet count.
20	externalBytes	External byte count (no trailing |).

Tunnel Midpoint Record Description

The tunnel midpoint record displays the internal and external packets and bytes for the tunnel head and uses the following format:

t|*<headAddr><tun_id>*|*<creationSysUpTime>*|
<internalPackets>|*<internalBytes>*|*<externalPackets>*|*<externalBytes>*

Table 3 describes the fields in the tunnel midpoint record.

Table 3 Tunnel Midpoint Record Fields

Maximum Field Length	Field	Description
2	*<recordType>*	**t** means that the record contains TE tunnel midpoint data.
27	headAddr*<space>*tun_id	The IP address of the tunnel head and tunnel interface number.
11	creationSysUpTime	How long the system had been running when the record was first created.
21	internalPackets	Internal packet count.
21	internalBytes	Internal byte count.
21	externalPackets	External packet count.
20	externalBytes	External byte count (no trailing |).

SUMMARY STEPS

1. **more system:/vfiles/tmstats_ascii**
2. Interpret the header and record information in the tmstats_ascii file.

DETAILED STEPS

Step 1 **more system:/vfiles/tmstats_ascii**

Enter this command on the backbone router to view the statistics in the ASCII file. For example:

```
Router# more system:/vfiles/tmstats_ascii

VERSION 1|ADDR 172.27.32.24|AGGREGATION TrafficMatrix.ascii|SYSUPTIME 41428|routerUTC
3104467160|NTP unsynchronized|DURATION 1|
p|10.1.0.0/16|242|1|50|2|100
p|172.27.32.0/22|242|0|0|0|0
```

This is an example of a tmstats_ascii file. The example contains a header information and two records. The header information and each record begin on a separate line. A bar (|) separates consecutive fields within a header or record. The first field in a record specifies the type of record.

Step 2 Interpret the header and record information in the tmstats_ascii file.

Each tmstats_ascii file displayed consists of header information and records. The file in the example in Step 1 contains header information and two destination prefix records.

Refer to the following sections for a description of header and record information:

- Header information—"tmstats_ascii File Header Description" section on page 16

- Destination prefix record (dynamic label switching or traffic engineering (TE) tunnel data)—"Destination Prefix Record Description" section on page 17
- Tunnel midpoint record (TE tunnel midpoint data)—"Tunnel Midpoint Record Description" section on page 18

Viewing Information in the tmasinfo File: BGP Neighbor Autonomous Systems for IGP Destinations

Perform the following task to view information in the tmasinfo file about BGP neighbor autonomous systems (ASs) for IGP destinations.

The TMS feature also displays the BGP neighbor ASs associated with each IGP destination. You can display all the neighbor ASs for any IGP destination. The tmsasinfo file is in ASCII format. It is the only format provided for this data.

Before you view the statistics in the tmsasinfo file, you need to understand the following:

- Header Format for tmsasinfo File, page 19
- Neighbor AS Record in tmsasinfo File, page 20

Header Format for tmsasinfo File

The file header provides the address of the router and indicates how much time the router used to collect and export the data. The file header uses the following format:

VERSION 1|**ADDR***<address>*|**AGGREGATION** ASList.ascii|**SYSUPTIME**<seconds>|**routerUTC** *<routerUTC>*|**DURATION***<aggregateTime>*|

Table 4 describes the fields in the file header.

Table 4 Fields in the tmsasinfo File Header

Maximum Field Length	Field	Description
5	VERSION	File format version
15	ADDR	The IP address of the router
20	AGGREGATION	The type of data being aggregated
10	SYSUPTIME	The time of export (in seconds) since router booted
10	routerUTC	The time of export (in seconds) since 1900-01-01, as determined by the router
10	DURATION	The time needed to capture the data (in seconds)

Neighbor AS Record in tmsasinfo File

The neighbor AS record displays the neighbor AS and the underlying prefix/mask for each BGP route. The record uses the following format:

<nonrecursivePrefix/Mask>|*<AS>*|*<destinationPrefix/Mask>*

Table 5 describes the fields in the neighbor AS record.

Table 5 Neighbor AS Record Fields

Maximum Field Length	Field	Description
18	nonrecursivePrefix/Mask	The IP prefix address/mask (a.b.c.d/len format) for this IGP route
5	AS	The neighbor AS
18	destinationPrefix/Mask	The prefix/mask for the Forwarding Information Base (FIB) entry (typically BGP route)

SUMMARY STEPS

1. **more system:/vfiles/tmsasinfo**
2. View the header and record information in the tmsasinfo file.

DETAILED STEPS

Step 1 **more system:/vfiles/tmsasinfo**

Enter this command on the backbone router to view the statistics in the tmsasinfo ASCII file. For example:

```
Router# more system:/vfiles/tmsasinfo

VERSION 1|ADDR 10.10.10.10|AGGREGATION ASList.ascii|SYSUPTIME 619855|routerUTC
3334075555|DURATION 0
10.1.1.2/32|65535|192.168.1.0/24

This is an example of a tmsasinfo file. The example contains a header information and one
record. The header information and each record begin on a separate line. A bar (|)
separates consecutive fields within a header or record.
```

Step 2 View the header and record information in the tmasinfo file.

Refer to the following sections for a description of header and record information:

- Header information—"Header Format for tmsasinfo File" section on page 19.
- Neighbor AS Record—"Neighbor AS Record in tmsasinfo File" section on page 20. The file displays BGP ASs associated with each IGP destination.

Verifying Cisco Express Forwarding Network Accounting Information

Perform the following task to verify that Cisco Express Forwarding networking accounting information is as you expected.

SUMMARY STEPS

1. **show ip cef summary**
2. **show ip cef** *interface-type number* **detail**

DETAILED STEPS

Step 1 **show ip cef summary**

Use this command to display the collected Cisco Express Forwarding network accounting information. For example:

```
Router# show ip cef summary

IP CEF with switching (Table Version 19), flags=0x0
  19 routes, 0 reresolve, 0 unresolved (0 old, 0 new), peak 1
  19 leaves, 17 nodes, 19960 bytes, 58 inserts, 39 invalidations
  0 load sharing elements, 0 bytes, 0 references
  universal per-destination load sharing algorithm, id E3296D5B
  3(1) CEF resets, 0 revisions of existing leaves
  Resolution Timer: Exponential (currently 1s, peak 1s)
  0 in-place/0 aborted modifications
  refcounts:  4628 leaf, 4608 node

Adjacency Table has 7 adjacencies
```

This command shows sample accounting information on a router with Central Cisco Express Forwarding enabled. In this example, the Cisco Express Forwarding table contains a total or 19 entries, 0 entries need to be reresolved, 0 entries do not have resolved recursions, and the highest number of unresolved entries is 1. The Cisco Express Forwarding Trie contains 19 leaves and 17 nodes, which take up 19960 bytes of memory. The number of routes inserted into the table is 58 and 39 routes have been invalidated. This command shows no load sharing elements. The per-destination load sharing algorithm is configured and the identifier is E3296D5D.

The following command is sample output for a router with distributed Cisco Express Forwarding enabled:

```
Router# show ip cef summary

IP Distributed CEF with switching (Table Version 36), flags=0x0
  16 routes, 0 reresolve, 0 unresolved (0 old, 0 new), peak 1
  19 leaves, 17 nodes, 19960 bytes, 39 inserts, 20 invalidations
  0 load sharing elements, 0 bytes, 0 references
  universal per-destination load sharing algorithm, id E3296D5B
  2(0) CEF resets, 0 revisions of existing leaves
  Resolution Timer: Exponential (currently 1s, peak 1s)
  0 in-place/0 aborted modifications
  refcounts:  4628 leaf, 4608 node
```

Step 2 **show ip cef** *interface-type number* **detail**

Use this command to show detailed Cisco Express Forwarding network accounting information for a specified interface type and number. The following is sample output from the **show ip cef detail** command for interface Ethernet 0. It shows all the prefixes resolving through adjacency pointing to next hop interface Ethernet 0/0 and next hop interface IP address 172.29.233.33.

For example, for Ethernet interface 0, IP address 172.29.233.33:

```
Router# show ip cef ethernet 0/0 detail

IP Distributed CEF with switching (Table Version 136808)

 45800 routes, 8 unresolved routes (0 old, 8 new)
 45800 leaves, 2868 nodes, 8444360 bytes,
 136808 inserts, 91008 invalidations
 1 load sharing elements, 208 bytes, 1 references
 1 CEF resets, 1 revisions of existing leaves
 refcounts: 527343 leaf, 465638 node

 172.29.233.33/32, version 7417, cached adjacency 172.29.233.33
 0 packets, 0 bytes,
   Adjacency-prefix
   via 172.29.233.33, Ethernet0/0, 0 dependencies

 next hop 172.29.233.33, Ethernet0/0
   valid cached adjacency
 0 packets, 0 bytes switched through the prefix
 tmstats: external 0 packets, 0 bytes
      internal 0 packets, 0 bytes
```

Configuration Examples for Configuring Cisco Express Forwarding Network Accounting

The following sections contain configuration examples for Cisco Express Forwarding accounting:

Configuring Cisco Express Forwarding Network Accounting: Example

The following example shows how to enable the collection of Cisco Express Forwarding accounting information:

```
configure terminal
!
ip cef accounting
end
```

Enabling a Backbone Router to Collect TMS Data: Example

The following example shows how to enable a backbone router to collect TMS data:

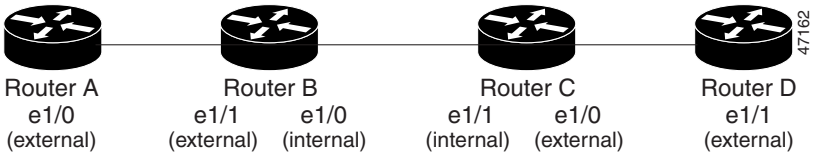
```
configure terminal
!
ip cef

ip cef accounting non-recursive
!
interface e1/0
 ip cef accounting non-recursive external
 end
```

For a sample backbone configuration, see the "IP Cisco Express Forwarding Nonrecursive Accounting Configuration: Example" section.

IP Cisco Express Forwarding Nonrecursive Accounting Configuration: Example

The following example shows an IP Cisco Express Forwarding accounting configuration. The example shows how to enable routers to count the number of internal and external packets and bytes that travel through the backbone routers. Figure 7 shows the sample backbone configuration.

Figure 7 Sample Backbone Configuration



Router A Configuration

```
Router(config)# ip cef
Router(config)# ip cef accounting non-recursive
Router(config)# interface e1/0
Router(config-if)# ip cef accounting non-recursive external
```

Router B Configuration: e1/1

```
Router(config)# ip cef
Router(config)# ip cef accounting non-recursive
Router(config)# interface e1/1
Router(config-if)# ip cef accounting non-recursive external
```

Router B Configuration: e1/0

```
Router(config)# interface e1/0
Router(config-if)# ip cef accounting non-recursive internal
```

Router C Configuration: e1/1:

```
Router(config)# ip cef
Router(config)# ip cef accounting non-recursive
Router(config)# interface e1/1
Router(config-if)# ip cef accounting non-recursive internal
```

Router C Configuration: e1/0

```
Router(config)# interface e1/0
```

```
Router(config-if)# ip cef accounting non-recursive external
```

Router D Configuration

```
Router(config)# ip cef
Router(config)# ip cef accounting non-recursive
Router(config)# interface e1/1
Router(config-if)# ip cef accounting non-recursive external
```

Interpreting the Statistics in the tmstats_ascii File: Example

The following example shows the contents of tmstats_ascii file:

```
Router# more system:/vfiles/tmstats_ascii

VERSION 1|ADDR 172.27.32.24|AGGREGATION TrafficMatrix.ascii|SYSUPTIME 41428|routerUTC
3104467160|NTP unsynchronized|DURATION 1|
p|10.1.0.0/16|242|1|50|2|100
p|172.27.32.0/22|242|0|0|0|0
```

This example contains header information and two destination prefix records. The records represent dynamic label switching or traffic engineering (TE) tunnel data indicated by the initial “p.”

Additional References

The following sections provide references related to configuring network accounting for Cisco Express Forwarding.

Related Documents

Related Topic	Document Title
List of the features documented in the Cisco Express Forwarding modules	*Cisco Express Forwarding Features Roadmap*
Overview of the Cisco Express Forwarding feature	*Cisco Express Forwarding Overview*
Tasks for verifying basic Cisco Express Forwarding and distributed Cisco Express Forwarding operation	*Configuring Basic Cisco Express Forwarding for Improved Performance, Scalability, and Resiliency in Dynamic Networks*
Tasks for enabling or disabling Cisco Express Forwarding or distributed Cisco Express Forwarding	*Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding to Customize Switching and Forwarding for Dynamic Networks*
Tasks for configuring load-balancing schemes for Cisco Express Forwarding	*Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic*
Tasks for configuring Cisco Express Forwarding consistency checkers	*Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards*
Tasks for configuring epochs for Cisco Express Forwarding tables	*Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables*
Tasks for customizing the display of recorded Cisco Express Forwarding events	*Customizing the Display of Recorded Cisco Express Forwarding Events*

Related Topic	Document Title
How to determine which Cisco IOS switching or forwarding path your packets are taking	*How to Verify Cisco Express Forwarding Switching*
How to use the Cisco Network Data Analyzer to view TMS	*Network Data Analyzer Installation and User Guide*
Commands for configuring and monitoring Cisco Express Forwarding	*Cisco IOS IP Switching Command Reference*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Feature Information for Configuring Cisco Express Forwarding Network Accounting

Table 6 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Release 12.2(1) or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the *Cisco Express Forwarding Features Roadmap*.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 6 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 6 Feature Information for Configuring Cisco Express Forwarding Network Accounting

Feature Name	Releases	Feature Configuration Information
This table is intentionally left blank because no features were introduced or modified in Cisco IOS Release 12.2(1) or later.	—	—

Glossary

AS—autonomous system. A collection of networks under a common administration sharing a common routing strategy. Autonomous systems are subdivided by areas. An autonomous system must be assigned a unique 16-bit number by the Internet Assigned Numbers Authority (IANA).

adjacency—A relationship formed between selected neighboring routers and end nodes for the purpose of exchanging routing information. Adjacency is based upon the use of a common media segment by the routers and nodes involved.

BGP—Border Gateway Protocol. An interdomain routing protocol that replaces Exterior Gateway Protocol (EGP). BGP exchanges reachability information with other BGP systems. It is defined by RFC 1163.

Cisco Express Forwarding—A Layer 3 switching technology. Cisco Express Forwarding can also refer to central Cisco Express Forwarding mode, one of two modes of Cisco Express Forwarding operation. Cisco Express Forwarding enables a Route Processor to perform express forwarding. Distributed Cisco Express Forwarding is the other mode of Cisco Express Forwarding operation.

distributed Cisco Express Forwarding—A type of Cisco Express Forwarding switching in which line cards (such as Versatile Interface Processor (VIP) line cards) maintain identical copies of the Forwarding Information Base (FIB) and adjacency tables. The line cards perform the express forwarding between port adapters; this relieves the Route Switch Processor of involvement in the switching operation.

FIB—forwarding information base. A component of Cisco Express Forwarding. The router uses the FIB lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The router maintains a mirror image of the forwarding information in an IP routing table.

IGP— Interior Gateway Protocol. An internet protocol used to exchange routing information within an autonomous system. Examples of common Internet IGPs include Interior Gateway Routing Protocol (IGRP), Open Shortest Path First (OSPF), and Routing Information Protocol (RIP).

label—A short fixed-length data construct that tells switching nodes how to forward data (packets or cells).

line card—A general term for an interface processor that can be used in various Cisco products. For example, a Versatile Interface Processor (VIP) is a line card for the Cisco 7500 series router.

prefix—The network address portion of an IP address. A prefix is specified by a network and mask and is generally represented in the format network/mask. The mask indicates which bits are the network bits. For example, 1.0.0.0/16 means that the first 16 bits of the IP address are masked, making them the network bits. The remaining bits are the host bits. In this example, the network number is 10.0.

RP—Route Processor. The processor module in the Cisco 7000 series routers that contains the CPU, system software, and most of the memory components that are used in the router. It is sometimes called a supervisory processor.

TE—traffic engineering. Techniques and processes that cause routed traffic to travel through the network on a path other than the one that would have been chosen if standard routing methods were used.

traffic engineering tunnel—A label-switched tunnel that is used for traffic engineering. Such a tunnel is set up through means other than normal Layer 3 routing; it is used to direct traffic over a path different from the one that Layer 3 routing could cause the tunnel to take.

TMS—Traffic Matrix Statistics. An IOS feature that enables an administrator to capture and analyze traffic data entering a backbone that is running the Border Gateway Protocol (BGP). This feature also allows an administrator to determine the neighbor autonomous systems of a BGP destination

VPN—Virtual Private Network. The result of a router configuration that enables IP traffic to use tunneling to travel securely over a public TCP/IP network.

VRF—A Virtual Private Network (VPN) routing/forwarding instance. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table. In general, a VRF includes the routing information that defines a customer VPN site that is attached to a PE router.

Customizing the Display of Recorded Cisco Express Forwarding Events

First Published: May 2, 2005
Last Updated: February 11, 2008

This module contains information about and instructions for customizing the display of recorded Cisco Express Forwarding events. You can customize the Cisco Express Forwarding event log display by specifying the size of the Cisco Express Forwarding event log or by choosing to display events by prefix and mask or by Cisco Express Forwarding Virtual Private Network (VPN) routing/forwarding instance (VRF).

Cisco Express Forwarding is an advanced Layer 3 IP switching technology. It optimizes network performance and scalability for all kinds of networks: those that carry small amounts of traffic and those that carry large amounts of traffic in complex patterns, such as the Internet and networks characterized by intensive web-based applications or interactive sessions.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Configuring the Display of Recorded Cisco Express Forwarding Events" section on page 9.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

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Prerequisites for Configuring the Display of Recorded Cisco Express Forwarding Events

Cisco Express Forwarding must be running on the networking device before you can customize the display of recorded Cisco Express Forwarding events.

Restrictions for Configuring the Display of Recorded Cisco Express Forwarding Events

If you enable Cisco Express Forwarding and then create an access list that uses the **log** keyword, the packets that match the access list are not Cisco Express Forwarding switched. They are fast switched. Logging disables Cisco Express Forwarding.

Information About Configuring the Display of Recorded Cisco Express Forwarding Events

Before customizing Cisco Express Forwarding event logging, you should understand the following:

- Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding, page 2
- Cisco Express Forwarding Event Log Overview, page 3

For links to information about other Cisco Express Forwarding and distributed Cisco Express Forwarding features that you can configure, go to the "Additional References" section on page 6.

Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding

Cisco Express Forwarding is enabled by default on most Cisco platforms running Cisco IOS software Release 12.0 or later. When Cisco Express Forwarding is enabled on a router, the Route Processor (RP) performs the express forwarding.

To find out if Cisco Express Forwarding is enabled on your platform, enter the **show ip cef** command. If Cisco Express Forwarding is enabled, you receive output that looks like this:

```
Router# show ip cef
```

```
Prefix              Next Hop            Interface
[...]
10.2.61.8/24        192.168.100.1       FastEthernet1/0/0
                    192.168.101.1       FastEthernet6/1
[...]
```

If Cisco Express Forwarding is not enabled on your platform, the output for the **show ip cef** command looks like this:

```
Router# show ip cef

%CEF not running
```

Distributed Cisco Express Forwarding is enabled by default on the Catalyst 6500 series switch, the Cisco 7500 series router, and the Cisco 12000 Series Internet Router. When distributed Cisco Express Forwarding is enabled on your platform, the line cards perform the express forwarding.

If Cisco Express Forwarding is not enabled on your platform, use the **ip cef** command to enable (central) Cisco Express Forwarding or the **ip cef distributed** command to enable distributed Cisco Express Forwarding.

Cisco Express Forwarding Event Log Overview

The Cisco Express Forwarding event log collects Cisco Express Forwarding events as they occur, even when debugging is not enabled. This allows the tracing of an event immediately after it occurs. Cisco technical personnel can use the event log to help resolve problems with the Cisco Express Forwarding feature.

When the Cisco Express Forwarding event log has reached its capacity, the oldest event is written over by the newest event. You can use the following commands to change the capacity of the Cisco Express Forwarding event log:

- The **ip cef table event-log** command allows you to increase or decrease the number of entries that the event log can hold.
- The **clear ip cef event-log** command allows you to clear all event log entries.

You can use the following commands to display Cisco Express Forwarding events:

- The **show ip cef events** command displays all recorded Cisco Express Forwarding forwarding information base (FIB) and adjacency events.
- The **debug ip cef** command and the **events** keyword record general Cisco Express Forwarding events as they occur.
- The **debug ip cef table** command enables the real-time collection of events that affect entries in the Cisco Express Forwarding tables.

How to Customize the Display of Recorded Cisco Express Forwarding Events

Perform the following tasks to customize Cisco Express Forwarding event logging and display logging events:

- Customizing Cisco Express Forwarding Event Logging, page 4 (optional)

- Displaying Cisco Express Forwarding Event-Log Information, page 5 (optional)

Customizing Cisco Express Forwarding Event Logging

This section contains information about and instructions for customizing Cisco Express Forwarding event logging.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef table event-log** [**size** *event-number*] [**match** *ip-prefix mask*] [**vrf** *vrf-name*]
4. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip cef table event-log** [**size** *event-number*] [**match** *ip-prefix mask*] [**vrf** *vrf-name*] **Example:** `Router(config)# ip cef table event-log size 25000`	Controls Cisco Express Forwarding table event-log characteristics. • The **size** *event-number* keyword-argument pair specifies the number of event entries. The range is from 1 to 4294967295. • The **match** keyword logs events that match the specified prefix and mask. • The *ip-prefix* argument is the specified IP prefix to match in dotted decimal format (A.B.C.D). • The *mask* argument is the network mask written as A.B.C.D. • The **vrf** *vrf-name* keyword-argument pair displays the named Virtual Private Network (VPN) routing/forwarding instance (VRF) Cisco Express Forwarding table.
Step 4	**exit** **Example:** `Router(config)# exit`	Exits to privileged EXEC mode.

Displaying Cisco Express Forwarding Event-Log Information

Perform the following task to display Cisco Express Forwarding event-log information.

SUMMARY STEPS

1. **enable**
2. **clear ip cef event-log**
3. **debug ip cef table**
4. **show ip cef events summary**
5. **show ip cef events within** *seconds*
6. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. For example:

```
Router> enable
```

Enter your password if prompted.

Step 2 **clear ip cef event-log**

Use this command to clear the Cisco Express Forwarding event-log buffer. For example:

```
Router# clear ip cef event-log
```

Step 3 **debug ip cef table**

Use this command to enable the collection of events that affect entries in the Cisco Express Forwarding tables. For example:

```
Router# debug ip cef table

01:25:46:CEF-Table:Event up, 10.1.1.1/32 (rdbs:1, flags:1000000)
01:25:46:CEF-IP:Checking dependencies of 0.0.0.0/0
01:25:47:CEF-Table:attempting to resolve 10.1.1.1/32
01:25:47:CEF-IP:resolved 10.1.1.1/32 via 10.9.104.1 to 10.9.104.1 Ethernet2/0/0
01:26:02:CEF-Table:Event up, default, 0.0.0.0/0 (rdbs:1, flags:400001)
01:26:02:CEF-IP:Prefix exists - no-op change
```

Step 4 **show ip cef events summary**

Use this command to display a summary of recorded Cisco Express Forwarding FIB and adjacency events. For example:

```
Router# show ip cef events summary

CEF table events summary:
     Storage for 10000 events (320000 bytes), 822/0 events recorded/ignored
     Matching all events, traceback depth 16
     Last event occurred 00:00:06.516 ago.
```

Step 5 **show ip cef events within** *seconds*

Use this command to display Cisco Express Forwarding events that occurred within (during) a specified number of seconds. For example, within 1 second:

```
Router# show ip cef events within 1

CEF table events (storage for 10000 events, 14 events recorded)
+00:00:00.000:[Default-table] *.*.*.*/*           New FIB table          [OK]
+00:00:00.000:[Default-table] 10.1.80.194/32      FIB insert in mtrie    [OK]
+00:00:00.000:[Default-table] 10.1.80.0/32        FIB insert in mtrie    [OK]
+00:00:00.000:[Default-table] 10.1.80.255/32      FIB insert in mtrie    [OK]
+00:00:00.004:[Default-table] 10.1.80.0/24        FIB insert in mtrie    [OK]
+00:00:00.004:[Default-table] 10.1.80.0/24        NBD up                 [OK]
+00:00:00.004:[Default-table] 239.224.0.0/4       FIB insert in mtrie    [OK]
+00:00:00.012:[Default-table] 10.1.80.0/24        NBD up                 [Ignr]
+00:00:00.012:[Default-table] 239.224.0.0/4       FIB remove             [OK]
+00:00:00.016:[Default-table] 239.224.0.0/4       FIB insert in mtrie    [OK]
+00:00:05.012:[Default-table] 239.224.0.0/4       FIB remove             [OK]
+00:00:05.012:[Default-table] 239.224.0.0/4       FIB insert in mtrie    [OK]
+00:00:28.440:[Default-table] 239.224.0.0/4       FIB remove             [OK]
+00:00:28.440:[Default-table] 239.224.0.0/4       FIB insert in mtrie    [OK]
First event occured at 00:00:36.568 (00:04:40.756 ago)
Last event occured at 00:01:05.008 (00:04:12.316 ago)
```

Step 6 **exit**

Use this command to exit to user EXEC mode. For example:

```
Router# exit
Router>
```

Configuration Examples for Configuring the Display of Recorded Cisco Express Forwarding Events

This section contains one configuration example for customizing the display of recorded Cisco Express Forwarding events:

- Customizing Cisco Express Forwarding Event Logging: Example, page 6

Customizing Cisco Express Forwarding Event Logging: Example

The following example shows how to enable event logging for Cisco Express Forwarding:

```
clear ip cef event-log
!
debug ip cef table
!
configure terminal
!
ip cef table event-log size 25000
exit
!
```

In this example, the Cisco Express Forwarding event log is configured to hold 25000 entries.

Additional References

The following sections provide references related to the customizing of the display of recorded Cisco Express Forwarding events.

Related Documents

Related Topic	Document Title
List of the features documented in the Cisco Express Forwarding modules	*Cisco Express Forwarding Features Roadmap*
Overview of the Cisco Express Forwarding feature	*Cisco Express Forwarding Overview*
Tasks for verifying basic Cisco Express Forwarding and distributed Cisco Express Forwarding operation	*Configuring Basic Cisco Express Forwarding for Improved Performance, Scalability, and Resiliency in Dynamic Networks*
Tasks for enabling or disabling Cisco Express Forwarding or distributed Cisco Express Forwarding	*Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding to Customize Switching and Forwarding for Dynamic Networks*
Tasks for configuring load-balancing schemes for Cisco Express Forwarding	*Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic*
Tasks for configuring Cisco Express Forwarding consistency checkers	*Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards*
Tasks for configuring epochs for Cisco Express Forwarding tables	*Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables*
Tasks for configuring and verifying Cisco Express Forwarding network accounting	*Configuring Cisco Express Forwarding Network Accounting*
Causes of common Cisco Express Forwarding-related error messages on platforms running distributed Cisco Express Forwarding switching (Cisco 7500 series routers and Cisco 12000 series Internet routers) and how to troubleshoot them	*Troubleshooting Cisco Express Forwarding-Related Error Messages*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Feature Information for Configuring the Display of Recorded Cisco Express Forwarding Events

Table 1 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Release 12.2(1) or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the *Cisco Express Forwarding Features Roadmap*.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 1 Feature Information for Configuring the Display of Recorded Cisco Express Forwarding Events

Feature Name	Releases	Feature Configuration Information
This table is intentionally left blank because no features were introduced or modified in Cisco IOS Release 12.2(1) or later. This table will be updated when feature information is added to this module.	—	—

Glossary

adjacency—A relationship formed between selected neighboring routers and end nodes for the purpose of exchanging routing information. Adjacency is based upon the use of a common media segment by the routers and nodes involved.

Cisco Express Forwarding—A Layer 3 switching technology. Cisco Express Forwarding can also refer to central Cisco Express Forwarding mode, one of two modes of Cisco Express Forwarding operation. Cisco Express Forwarding enables a Route Processor to perform express forwarding. Distributed Cisco Express Forwarding is the other mode of Cisco Express Forwarding operation.

distributed Cisco Express Forwarding—A mode of Cisco Express Forwarding operation in which line cards (such as Versatile Interface Processor (VIP) line cards) maintain identical copies of the forwarding information base (FIB) and adjacency tables. The line cards perform the express forwarding between port adapters; this relieves the Route Switch Processor of involvement in the switching operation.

FIB—forwarding information base. A component of Cisco Express Forwarding that is conceptually similar to a routing table or information base. The router uses the FIB lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The router maintains a mirror image of the forwarding information in an IP routing table.

line card—A general term for an interface processor that can be used in various Cisco products. For example, a Versatile Interface Processor (VIP) is a line card for the Cisco 7500 series router.

prefix—The network address portion of an IP address. A prefix is specified by a network and mask and is generally represented in the format network/mask. The mask indicates which bits are the network bits. For example, 1.0.0.0/16 means that the first 16 bits of the IP address are masked, making them the network bits. The remaining bits are the host bits. In this example, the network number is 10.0.

VPN—Virtual Private Network. The result of a router configuration that enables IP traffic to use tunneling to travel securely over a public TCP/IP network.

VRF—A Virtual Private Network (VPN) routing/forwarding instance. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table. In general, a VRF includes the routing information that defines a customer VPN site that is attached to a PE router.

Fast Switching

Configuring Fast Switching

First Published: February 11, 2008
Last Updated: July 11, 2008

This module describes how to configure fast switching on Cisco IOS devices and provides configuration guidelines for switching paths and tuning guidelines.

For a complete description of the commands in this module, refer to the *Cisco IOS IP Switching Command Reference*.

Note IP unicast fast switching is no longer supported on Cisco IOS Releases 12.2(25)S, 12.2(28)SB, 12.2(33)SRA, 12.2(33)SXH, 12.4(20)T and later releases. For these and later releases, components that do not support Cisco Express Forwarding will only work in Process Switched mode.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Configuring Fast Switching" section on page 18.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

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

Information About Configuring Fast Switching

Before you configure fast switching you should understand the following concepts:

Benefits of Fast Switching

Fast switching allows higher throughput by switching a packet using a cache created by the initial packet sent to a particular destination. Destination addresses are stored in the high-speed cache to expedite forwarding. Routers offer better packet-transfer performance when fast switching is enabled. Fast switching is enabled by default on all interfaces that support fast switching.

When packets are fast switched, the first packet is copied to packet memory and the destination network or host is found in the fast-switching cache. The frame is rewritten and sent to the outgoing interface that services the destination. Subsequent packets for the same destination use the same switching path. The interface processor computes the CRC.

Note IP unicast fast switching is no longer supported on Cisco IOS Releases 12.2(25)S, 12.2(28)SB, 12.2(33)SRA, 12.2(33)SXH, 12.4(20)T and later releases. For these and later releases, components that do not support Cisco Express Forwarding will only work in Process Switched mode.

Reasons for Disabling Fast Switching

Fast switching uses a cache created by previous packets to achieve a higher packet throughput. Packet transfer performance is generally better when fast switching is enabled. Fast switching also provides load sharing on a per-destination basis.

By default, fast switching is enabled on all interfaces that support fast switching. However, you may want to disable fast switching to save memory space on interface cards and to help avoid congestion when high-bandwidth interfaces are writing large amounts of information to low-bandwidth interfaces. This is especially important when using rates slower than T1.

Fast switching is not supported on serial interfaces using encapsulations other than HDLC.

Note Turning off fast switching increases system overhead because the packets are then process switched by the system's CPU.

For some diagnostics, such as debugging and packet-level tracing, you need to disable fast switching. Disabling fast switching causes the router to fall back to process switching the packets. If fast switching is running, you might only see the first packet to each destination in the output of any packet-level debugging commands. Subsequent packets to the same destination are fast switched. Many packet level

debugging commands cannot process packets that are fast switched. You might want to turn off fast switching temporarily to use process switching instead while you are trying to capture information to diagnose a problem.

AppleTalk Access Lists Automatically Fast Switched

AppleTalk access lists are automatically fast switched. Access list fast switching improves the performance of AppleTalk traffic when access lists are defined on an interface.

Refer to the "Configuring AppleTalk" chapter in the *Cisco IOS AppleTalk and Novell IPX Configuration Guide* for guidelines on creating and using access lists and configuring AppleTalk.

How to Configure Fast Switching

By default, fast switching is enabled on all interfaces that support fast switching. However, you may have reasons to disable fast switching (see the "Reasons for Disabling Fast Switching" section on page 2).

The tasks in this section include enabling fast switching for some software applications, disabling fast switching for other software applications, and managing the route cache associated with fast switching on the device:

Note Fast switching is not supported for the X.25 encapsulations.

Enabling Fast Switching of IPX Directed Broadcast Packets

To enable fast switching of Internet Packet Exchange (IPX) directed broadcast packets, perform the following task. This may be useful in certain broadcast-based applications that rely on helpering.

By default, Cisco IOS software switches IPX packets that are directed to the broadcast address. Fast switching of these packets is disabled. The default behavior is to process switch directed broadcast packets.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipx broadcast-fastswitching**

4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ipx broadcast-fastswitching** **Example:** `Router(config)# ipx broadcast-fastswitching`	Enables the router to fast switch IPX directed broadcast packets,
Step 4	**end** **Example:** `Router(config)# end`	Exits to privileged EXEC mode.

Disabling IPX Fast Switching

To disable IPX fast switching, perform the following task. IPX fast switching is enabled by default. You might want to disable fast switching for the following reasons:

- To save memory on the interface cards: fast-switching caches require more memory than those used for standard switching
- To avoid congestion on interface cards when a high-bandwidth interface is writing large amounts of information to a low-bandwidth interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no ipx route-cache**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface ethernet 0`	Configures an interface type and enters interface configuration mode. • The *type* argument is the type of interface to be configured. • The *number* argument is the port, connector, or interface card number. The numbers are assigned at the factory at the time of installation or when added to a system, and can be displayed with the **show interfaces** command.
Step 4	**no ipx route-cache** **Example:** `Router(config-if)# no ipx route-cache`	Disables IPX fast switching on an interface.
Step 5	**end** **Example:** `Router(config)# end`	Exits to privileged EXEC mode.

Adjusting the Route Cache for IPX

Adjusting the route cache allows you to control the size of the route cache, reduce memory consumption, and improve router performance. You accomplish these tasks by controlling the route cache size and route cache invalidation. The following sections describe these optional tasks:

- Controlling IPX Route Cache Size, page 5 (Optional)
- Controlling IPX Route Cache Entry Invalidation, page 6 (Optional)

Controlling IPX Route Cache Size

You can limit the number of entries stored in the IPX route cache to free up router memory and aid router processing.

Storing too many entries in the route cache can use a substantial amount of router memory, causing router processing to slow. This situation is most common on large networks that run network management applications for NetWare.

For example, if a network management station is responsible for managing all clients and servers in a very large (greater than 50,000 nodes) Novell network, the routers on the local segment can become inundated with route cache entries. You can set a maximum number of route cache entries on these routers to free up router memory and aid router processing.

To control IPX route cache size, perform the following task.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipx route-cache max-size** *size*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ipx route-cache max-size** *size* **Example:** `Router(config)# ipx route-cache max-size 10000`	Sets a maximum limit on the number of entries in the IPX route cache. • The *size* argument is maximum number of entries allowed in the IPX route cache. **Note** If the route cache has more entries than the specified limit, the extra entries are not deleted. However, they may be removed if route cache invalidation is in use. See the "“Controlling IPX Route Cache Entry Invalidation” section on page 6"for more information on invalidating route cache entries.
Step 4	**end** **Example:** `Router(config)# end`	Exits to privileged EXEC mode.

Controlling IPX Route Cache Entry Invalidation

You can configure the router to invalidate inactive fast-switch cache entries. If these entries remain invalidated for 1 minute, the router purges the entries from the route cache.

Purging invalidated entries reduces the size of the route cache, reduces memory consumption, and improves router performance. Purging entries also helps ensure accurate route cache information.

You specify the period of time that valid fast switch cache entries must be inactive before the router invalidates them. You can also specify the number of cache entries that the router can invalidate per minute.

To control IPX route cache entry invalidation, perform the following task.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipx route-cache inactivity-timeout** *period* [*rate*]
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ipx route-cache inactivity-timeout** *period* [*rate*] **Example:** `Router(config)# ipx route-cache inactivity-timeout 5 10`	Adjusts the period and rate of route cache invalidation because of inactivity. • The *period* argument is the number of minutes that a valid cache entry may be inactive before it is invalidated. Valid values are 0 through 65,535. A value of zero disables this feature. The default is 2. • The *rate* argument is the maximum number of inactive entries that may be invalidated per minute. Valid values are 0 through 65,535. The default rate is 0 (cache entries do not age). **Note** When you use the **ipx route-cache inactivity-timeout** command with the **ipx route-cache max-size** command, you can ensure a small route cache with fresh entries.
Step 4	**end** **Example:** `Router(config)# end`	Exits to privileged EXEC mode.

Enabling Padding of Odd-Length IPX Packets

Some IPX end hosts accept only even-length Ethernet packets. If the length of a packet is odd, the packet must be padded with an extra byte so that end host can receive it. By default, Cisco IOS software pads odd-length Ethernet packets.

Note However, there are cases in certain topologies where nonpadded Ethernet packets are forwarded onto a remote Ethernet network. Under specific conditions, you can enable padding on intermediate media as a temporary workaround for this problem. Note that you should perform this task only under the guidance of a customer engineer or other service representative.

To enable the padding of odd-length packets, perform the following task.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no ipx route-cache**
5. **ipx pad-process-switched-packets**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface serial 0`	Configures an interface type and enters interface configuration mode. • The *type* argument is the type of interface to be configured. • The *number* argument is the port, connector, or interface card number. The numbers are assigned at the factory at the time of installation or when added to a system, and can be displayed with the **show interfaces** command.
Step 4	**no ipx route-cache** **Example:** `Router(config-if)# no ipx route-cache`	Disables IPX fast switching

	Command or Action	Purpose
Step 5	**ipx pad-process-switched-packets** **Example:** `Router(config-if)# ipx pad-process-switched-packets`	Controls whether odd-length packets are padded so as to be sent as even-length packets on an interface.
Step 6	**end** **Example:** `Router(config-if)# end`	Exits to privileged EXEC mode.

Disabling AppleTalk Fast Switching

To disable AppleTalk fast switching on an interface, perform the following task. AppleTalk fast switching is enable by default.

See the "Reasons for Disabling Fast Switching" section on page 2 for information on when you might want to disable AppleTalk fast switching.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no appletalk route-cache**
5. **end**

DETAILED STEPS

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

	Command or Action	Purpose
Step 3	**interface** *type number* **Example:** `Router(config)# interface ethernet 0`	Configures an interface type and enters interface configuration mode. • The *type* argument is the type of interface to be configured. • The *number* argument is the port, connector, or interface card number. The numbers are assigned at the factory at the time of installation or when added to a system, and can be displayed with the **show interfaces** command.
Step 4	**no appletalk route-cache** **Example:** `Router(config-if)# no appletalk route-cache`	Disables AppleTalk fast switching.
Step 5	**end** **Example:** `Router(config-if)# end`	Exits to privileged EXEC mode.

Reenabling SMDS Fast Switching for IPX and AppleTalk Packets

Switched Multimegabit Data Service (SMDS) fast switching is enabled by default. To reenable SMDS fast switching on IPX and AppleTalk packets, if it has been disabled, perform the following task.

SMDS is a wide-area networking service offered by some Regional Bell Operating Companies (RBOCs). SMDS fast switching of IPX and AppleTalk packets provides faster packet transfer on serial links with speeds above 56 kbps. Use fast switching if you use high-speed, packet-switched, datagram-based WAN technologies such as Frame Relay offered by service providers.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **encapsulation smds**
5. **ipx route-cache**
6. **appletalk route-cache**
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface serial 0`	Configures an interface type and enters interface configuration mode. • The *type* argument is the type of interface to be configured. • The *number* argument is the port, connector, or interface card number. The numbers are assigned at the factory at the time of installation or when added to a system, and can be displayed with the **show interfaces** command.
Step 4	**encapsulation smds** **Example:** `Router(config-if)# encapsulation smds`	Enables SMDS on the desired interface.
Step 5	**ipx route-cache** **Example:** `Router(config-if)# ipx route-cache`	Enables IPX fast switching on the interface.
Step 6	**appletalk route-cache** **Example:** `Router(config-if)# appletalk route-cache`	Enables AppleTalk fast switching on all supported interfaces.
Step 7	**end** **Example:** `Router(config-if)# end`	Exits to privileged EXEC mode.

Disabling DECnet Fast Switching

To disable fast switching of DECnet packets, perform the following task.

By default, DECnet routing software implements fast switching of DECnet packets. You might want to disable fast switching to save memory space on interface cards and to help avoid congestion when high-bandwidth interfaces are writing large amounts of information to low-bandwidth interfaces. Disabling fast switching is especially important when rates slower than T1 are used.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no decnet route-cache**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface serial 0/0`	Configures an interface type and enters interface configuration mode. • The *type* argument is the type of interface to be configured. • The *number* argument is the port, connector, or interface card number. The numbers are assigned at the factory at the time of installation or when added to a system, and can be displayed with the **show interfaces** command.
Step 4	**no decnet route-cache** **Example:** `Router(config-if)# no decnet route-cache`	Disables fast switching of DECnet packets on a per-interface basis.
Step 5	**end** **Example:** `Router(config-if)# end`	Exits to privileged EXEC mode.

Disabling ISO CLNS Fast Switching Through the Cache

Perform the following task to disable See the "Reasons for Disabling Fast Switching" section on page 2 for information on why you might want to disable ISO CLNS fast switching through the cache.

SUMMARY STEPS

1. **enable**
2. **configure terminal**

3. **interface** *type number*
4. **no clns route-cache**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface ethernet 0`	Configures an interface type and enters interface configuration mode. • The *type* argument is the type of interface to be configured. • The *number* argument is the port, connector, or interface card number. The numbers are assigned at the factory at the time of installation or when added to a system, and can be displayed with the **show interfaces** command.
Step 4	**no clns route-cache** **Example:** `Router(config-if)# no clns route-cache`	Disables fast switching. **Note** The cache still exists and is used after the **no clns route-cache** command is entered, but the software does not do fast switching through the cache.
Step 5	**end** **Example:** `Router(config-if)# end`	Exits to privileged EXEC mode.

Configuration Examples for Configuring Fast Switching

This section provides the following examples for configuring fast switching

Enabling Fast Switching of IPX Directed Broadcast Packets: Example

The following example shows how to enable fast switching of IPX directed broadcast packets:

```
configure terminal
ipx broadcast-fastswitching
end
```

Disabling IPX Fast Switching: Example

The following example shows how to disable IPX fast switching:

```
configure terminal
interface ethernet 0
 no ipx route-cache
 end
```

Adjusting the Route Cache for IPX: Examples

The following examples show how to adjust the route cache for IPX. This allows you to control the size of the route cache, reduce memory consumption, and improve router performance.

Controlling IPX Route Cache Size: Example

The following example show how to control the IPX route cache size:

```
configure terminal
ipx route-cache max-size 10000
end
```

In this example the cache size is set to 10000 entries. If the route cache has more entries than the specified limit, the extra entries are not deleted. However, they may be removed if route cache invalidation is in use. See the ““Controlling IPX Route Cache Entry Invalidation: Example” section on page 14”for a configuration example.

Controlling IPX Route Cache Entry Invalidation: Example

The following example shows how to control IPX route cache entry invalidations;

```
configure terminal
ipx route-cache inactivity-timeout 5 10
end
```

In this example, the inactivity period is set to 5 minutes and sets a maximum of 10 entries that can be invalidated per minute.

When you use the **ipx route-cache inactivity-timeout** command with the **ipx route-cache max-size** command, you can ensure a small route cache with fresh entries.

Enabling Padding of Odd-Length IPX Packets: Example

Note Use the **ipx pad-process-switched-packets** command only under the guidance of a customer engineer or other service representative.

The following example shows how to enable padding of odd-length IPX packets:

```
configure terminal
interface serial 0
 no ipx route-cache
 ipx pad-process-switched-packets
 end
```

In this example, the Cisco IOS software pads odd-length packets so that they are sent as even-length packets on serial interface 0.

Disabling AppleTalk Fast Switching: Example

The following example shows how to disable AppleTalk fast switching:

```
configure terminal
interface ethernet 0
 no appletalk route-cache
 end
```

Reenabling SMDS Fast Switching for IPX and AppleTalk Packets: Example

The following example shows how to reenable SMDS fast switching for IPX and AppleTalk packets if fast switching is disabled:

```
configure terminal
interface serial 0
 encapsulation smds
 ipx route-cache
 appletalk route-cache
 end
```

Disabling DECnet Fast Switching: Example

The following example show how to disable DECnet fast switching:

```
configure terminal
interface serial 0/0
 no decnet route-cache
 end
```

DECnet fast switching is disabled on a per-interface basis.

Disabling ISO CLNS Fast Switching Through the Cache: Example

The following example shows how to disable ISO CLNS fast switching through the cache:

```
configure terminal
interface ethernet 0
 no clns route-cache
 end
```

Additional References

The following sections provide references related to the Configuring Fast Switching feature.

Related Documents

Related Topic	Document Title
Overview of switching paths available on Cisco IOS devices	*Cisco IOS Switching Paths Overview*
Description of IP Switching commands	*Cisco IOS IP Switching Command Reference*
Information on how to configure AppleTalk	• *Cisco IOS AppleTalk Configuration Guide, Release 12.2SR* • *Cisco IOS AppleTalk Configuration Guide, Release 12.4T*
Description of AppleTalk commands	*Cisco IOS AppleTalk Command Reference*
Information on how to configure Novell IPX	*Cisco IOS Novell IPX Configuration Guide*, Release 12.4T
Description of the IPX commands	*Cisco IOS Novell IPX Command Reference*
Information on how to configure SMDS packet-switched software	"Configuring SDMS" chapter in the *Access and Communication Servers Configuration Guide*
Description of SMDS commands	"SMDS Commands" chapter in the *Access and Communication Servers Command Reference*
Information on how to configure DECnet	• *Cisco IOS DECnet Configuration Guide*, Release 12.2SR • *Cisco IOS DECnet Configuration Guide*, Release 12.4T
Description of DECnet command	*Cisco IOS DECnet Command Reference*
Information on how to configure ISO CLNS	• *Cisco IOS ISO CLNS Configuration Guide,* Release 12.2SR • *Cisco IOS ISO CLNS Configuration Guide*, Release 12.4T
Description of ISO CLNS commands	*Cisco IOS ISO CLNS Command Reference*

Standards

Standard	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Command Reference

This feature uses no new or modified commands.

Feature Information for Configuring Fast Switching

Table 1 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Releases 12.2(1) or 12.0(3)S or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the "Cisco IOS IP Switching Roadmap" module.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 1 Feature Information for Configuring Fast Switching

Feature Name	Releases	Feature Information
This table is intentionally left blank because no features were introduced or modified in Cisco IOS Release 12.2(1) or later. This table will be updated when feature information is added to this module.	—	—

Glossary

AppleTalk—A multilayered protocol providing internetwork routing, transaction and data stream service, naming service, and comprehensive file and print sharing.

IPX—Internetwork Packet Exchange. A NetWare protocol that routes outgoing data packets across a network. Every NetWare network has a unique address assigned when its servers are configured. IPX routers use this address to route packets through an internetwork.

ISO CLNS—International Organization for Standardization (ISO) Connectionless Network Service (CLNS). A standard for the network layer of the Open System Interconnection (OSI) model. CLNS is the OSI network layer service that does not require a circuit to be established before data is transmitted. CLNS routes messages to their destination independently of any other message.

NetWare—Popular distributed network operating system developed by Novell.

SMDS—Switched Multimegabit Data Service. A wide-area networking service offered by some Regional Bell Operating Companies (RBOCs).

Multicast Distributed Switching

Configuring Multicast Distributed Switching

First Published: February 11, 2008
Last Updated: May 5, 2008

This module describes the required and optional tasks for configuring Multicast Distributed Switching (MDS).

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

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Configuring Multicast Distributed Switching" section on page 13.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

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

Information About Multicast Distributed Switching

This section provides information that you should understand about MDS.

Advantages of Multicast Distributed Switching

Prior to MDS, IP multicast traffic was always switched at the Route Processor (RP) in the Route Switch Processor (RSP)-based platforms.

Switching multicast traffic at the RP had the following disadvantages:

- The load on the RP increased. This affected important route updates and calculations (for Border Gateway Protocol (BGP), among others) and could stall the router if the multicast load was substantial.
- The net multicast performance was limited to what a single RP could switch.

MDS solves these problems by performing distributed switching of multicast packets received at the line cards (Versatile Interface Processors [VIPs] in the case of RSP, and line cards in the case of Cisco 12000 series router). The line card is the interface card that houses the VIPs (in the case of RSP) and the line card (in the case of Cisco 12000 series router). MDS is accomplished using a forwarding data structure called a Multicast Forwarding Information Base (MFIB), which is a subset of the routing table. A copy of MFIB runs on each line card and is always kept up to date with the MFIB table of the RP.

MDS can work in conjunction with Cisco Express Forwarding or unicast distributed fast switching (DFS).

Starting with Cisco IOS Release 11.2GS, IP multicast traffic can be distributed switched on RSP-based platforms with VIPs. MDS is the only multicast switching method on the Cisco 12000 series router starting with Cisco IOS Release 11.2(11)GS.

Multicast Distributed Switching Is Disabled by Default

On the Cisco 7500 series router, the default is IP multicast fast switching. MDS is an option that is available and is disabled by default.

On the Cisco 12000 series routers, MDS is also disabled by default. To switch multicast packets on the Cisco 12000 series router, you need to configure all interfaces for MDS. MDS is the only multicast switching mode for the Cisco 12000 series router.

If MDS is not enabled on an incoming interface that is capable of MDS, incoming multicast packets are not distributed switched; the multicast packets are fast switched at the RP. Also, if the incoming interface is not capable of MDS, packets are fast switched or process-switched at the RP.

If MDS is enabled on the incoming interface, but at least one of the outgoing interfaces cannot fast switch, packets are process switched.

Note We recommended that you disable fast switching on any interface when MDS is enabled.

How to Configure Multicast Distributed Switching

This section contains the following tasks to configure MDS and to monitor and maintain MDS once it is configured:

Configuring Multicast Distributed Switching

Perform the following task to configure MDS. To configure MDS, you must enable it globally and on at least one interface because MDS is an attribute of the interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip multicast-routing distributed**
4. **interface** *type number*
5. **ip route-cache distributed**
6. **ip mroute-cache distributed**
7. Repeat Steps 4 through 6 for each interface that you want to perform MDS.
8. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip multicast-routing distributed** **Example:** `Router(config)# ip multicast-routing distributed`	Enables IP multicast routing. • The **distributed** keyword enables MDS globally.

	Command or Action	Purpose
Step 4	**interface** *type number* **Example:** `Router(config)# interface ethernet 0`	Configures an interface type and enters interface configuration mode. • The *type* argument is the type of interface to be configured. • The *number* argument is the port, connector, or interface card number. The numbers are assigned at the factory at the time of installation or when added to a system, and can be displayed with the **show interfaces** command.
Step 5	**ip route-cache distributed** **Example:** `Router(config-if)# ip route-cache distributed`	Enables distributed switching on the RSP. **Note** This step is required on the RSP platform only.
Step 6	**ip mroute-cache distributed** **Example:** `Router(config-if)# ip mroute-cache distributed`	Enables MDS on the interface. For Cisco 7500 series routers, this keyword is optional; if it is omitted, fast switching occurs. For Cisco 12000 series, this keyword is required because the Cisco 12000 series does only distributed switching.
Step 7	Repeat Steps 4 through 6 for each interface that you want to perform MDS.	—
Step 8	**end** **Example:** `Router(config-if)# end`	Exits to privileged EXEC mode.

Note When you enable an interface to perform distributed switching of incoming multicast packets, you are configuring the physical interface, not the logical interface (subinterface). All subinterfaces are included in the physical interface.

Maintaining Multicast Distributed Switching

This section contains the following tasks to maintain and monitor MDS:

- Maintaining Multicast Distributed Switching on the Line Card, page 5
- Maintaining Multicast Distributed Switching on the Route Processor, page 5

Maintaining Multicast Distributed Switching on the Line Card

Perform the following task to maintain MDS on the line card.

SUMMARY STEPS

1. **enable**
2. **clear ip mds forwarding**
3. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**clear ip mds forwarding** **Example:** `Router# clear ip mds forwarding`	Clears MDS information from the router, • Clears the Multicast Forwarding Information Base (MFIB) table of the line card and resynchronizes it with the RP.
Step 3	**exit** **Example:** `Router# exit`	Exits to user EXEC mode.

Maintaining Multicast Distributed Switching on the Route Processor

Perform the following task to maintain MDS on the RP.

SUMMARY STEPS

1. **enable**
2. **clear ip mroute** {***** | *group* [*source*]}
3. **clear ip pim interface count**
4. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**clear ip mroute** {* | *group* [*source*]} **Example:** `Router# clear ip mroute *`	Deletes entries from the IP multicast routing table. • The * (asterisk) keyword deletes all entries from the IP multicast routing table. • The *group* argument is either of the following: – Name of the multicast group, as defined in the Domain Name System (DNS) hosts table or with the **ip host** command. – IP address of the multicast group. This is a multicast IP address in four-part dotted-decimal notation. • The *source* argument is a name or address of a multicast source that is sending to the group. A source need not be a member of the group. If you specify a group name or address, you can also specify a source name or address.
Step 3	**clear ip pim interface count** **Example:** `Router# clear ip pim interface count`	Clears all line card counts or packet counts.
Step 4	**exit** **Example:** `Router# exit`	Exits to user EXEC mode.

Monitoring Multicast Distributed Switching

This section contains the following tasks to maintain and monitor MDS:

- Monitoring Multicast Distributed Switching on the Line Card, page 6
- Monitoring Multicast Distributed Switching on the Route Processor, page 8

Monitoring Multicast Distributed Switching on the Line Card

Perform the following task to monitor MDS on the line cards.

Remember that to reach a line card's console, enter the **attach** *slot#* command, using the slot number where the line card resides.

```
Router> attach 1
LC-Slot1> enable
LC-Slot1#
```

SUMMARY STEPS

1. **enable**
2. **show ip mds forwarding** [*group-address*]
3. **show ip mds summary**
4. **exit**

DETAILED STEPS

Step 1 enable

Use this command to enable privileged EXEC mode. Enter a password, if prompted. For example:

```
Router> enable
Router#
```

Step 2 show ip mds forwarding [*group-address*]

Use this command to display the MFIB table, forwarding information, related flags, and counts. For example:

```
Router# show ip mds forwarding

IP multicast MDFS forwarding information and statistics:

Flags: N - Not MDFS switchable, F - Not all MDFS switchable, O - OIF Null
       R - In-ratelimit, A - In-access, M - MTU mismatch, P - Register set

Interface state: Interface, Next-Hop, Mac header

(*, 224.2.170.73),

 Incoming interface: Null
  Pkts: 0, last used: never, Kbps: 0, fast-flags: N
  Outgoing interface list: Null

(192.168.62.86, 224.2.170.73) [31]
  Incoming interface: Fddi3/0/0
  Pkts: 3034, last used: 00:00:00, Kbps: 0, fast-flags: M
  Outgoing interface list:
```

Step 3 show ip mds summary

Use this command to display a summary of the MFIB. For example:

```
Router# show ip mds summary

IP multicast MDFS forwarding information and statistics:

Flags: N - Not MDFS switchable, F - Not all MDFS switchable, O - OIF Null
       R - In-ratelimit, A - In-access, M - MTU mismatch, P - Register set
Interface state: Interface, Next-Hop, Mac header

(*, 224.2.170.73),
  Incoming interface: Null
  Pkts: 0, last used: never, Kbps: 0, fast-flags: N

(192.168.62.86, 224.2.170.73) [31]
  Incoming interface: Fddi3/0/0
  Pkts: 3045, last used: 00:00:03, Kbps: 0, fast-flags: M
```

```
(192.168.3.7, 224.2.170.73) [334]
  Incoming interface: Fddi3/0/0
  Pkts: 0, last used: never, Kbps: 0, fast-flags: M
```

Step 4 **exit**

Use this command to exit to user EXEC mode. For example:

```
Router# exit
Router>
```

Monitoring Multicast Distributed Switching on the Route Processor

Perform the following task to monitor MDS on the RP.

SUMMARY STEPS

1. **enable**
2. **show ip mds stats** [**switching | linecard**
3. **show mds interface**
4. **show interface stats**
5. **exit**

DETAILED STEPS

Step 1 **enable**

Use this command to enable privileged EXEC mode. Enter a password, if prompted. For example:

```
Router> enable
Router#
```

Step 2 **show ip mds stats** [**switching | linecard**]

Use this command to display switching statistics or line card statistics for MDS. This example displays switching statistics:

```
Router# show ip mds stats switching

Slot Total       Switched    Drops      RPF        Punts      Failures
                                                              (switch/clone)
 1   0           0           0          0          4          0/0
 3   20260925    18014717    253        93         2247454    1/0
```

This example displays linecard statistics:

```
Router# show ip mds linecard

Slot      Status    IPC(seq/max) Q(high/route)  Reloads
 1        active    10560/10596      0/0            9
 3        active    11055/11091      0/0            9
```

Step 3 **show mds interface**

Use this command to display MDS interfaces. For example:

```
Router# show mds interface

Interface               SW-Index  HW-Index  HW IDB      FS Vector   VRF
```

```
Ethernet1/0/0            2         1         0x60C2DB40  0x602FB7A4 default
Ethernet1/0/1            3         2         0x60C32280  0x603D52B8 default
Ethernet1/0/2            4         3         0x60C35E40  0x602FB7A4 default
Ethernet1/0/3            5         4         0x60C39E60  0x603D52B8 default
Ethernet1/0/4            6         5         0x60C3D780  0x602FB7A4 default
Ethernet1/0/5            7         6         0x60C41140  0x602FB7A4 default
Ethernet1/0/6            8         7         0x60C453A0  0x602FB7A4 default
Ethernet1/0/7            9         8         0x60C48DC0  0x602FB7A4 default
POS2/0/0                 10        9         0x0                    default
POS3/0/0                 11        10        0x0                    default
Virtual-Access1          13        11        0x0                    default
Loopback0                14        12        0x0                    default
Tunnel0                  15        23        0x61C2E480  0x603D52B8  vrf1
Tunnel1                  16        24        0x61C267E0  0x603D52B8  vrf2
Ethernet1/0/3.1          17        4         0x60C39E60  0x603D52B8  vrf1
Ethernet1/0/3.2          18        4         0x60C39E60  0x603D52B8  vrf2
```

Step 4 show interface stats

Use this command to display numbers of packet that were process switched, fast switched, and distributed switched. For example:

```
Router# show interface stats

GigabitEthernet0/0
          Switching path    Pkts In   Chars In   Pkts Out  Chars Out
               Processor          0          0        225      77625
             Route cache          0          0          0          0
  Multi-Processor Fwding        950     221250        500      57000
                 Total          950     221250        725     134625
GigabitEthernet0/1
          Switching path    Pkts In   Chars In   Pkts Out  Chars Out
               Processor          1         60        226      77685
             Route cache          0          0          0          0
  Multi-Processor Fwding        500      57000        500      57000
                 Total          501      57060        726     134685
GigabitEthernet0/2
          Switching path    Pkts In   Chars In   Pkts Out  Chars Out
               Processor          1         60        226      77685
             Route cache          0          0          0          0
  Multi-Processor Fwding          0          0          0          0
                 Total          1         60        226      77685
FastEthernet1/0
          Switching path    Pkts In   Chars In   Pkts Out  Chars Out
               Processor      34015    5331012       1579     158190
             Route cache          0          0          0          0
                 Total        34015    5331012       1579     158190
```

Step 5 exit

Use this command to exit to user EXEC mode. For example:

```
Router# exit
Router>
```

Configuration Examples for Configuring Multicast Distributed Switching

This section contains examples for configuring MDS.

Configuring Multicast Distributed Switching: Example

The following example show how to enables MDS:

```
configure terminal
ip multicast-routing distributed
interface pos 1/0/0
 ip route-cache distributed
 ip mroute-cache distributed
 end
```

The **ip route-cache distributed** command is needed on the RSP only, not on the GSR.

Maintaining Multicast Distributed Switching: Examples

This section contains the following examples for maintaining MDS:

Maintaining Multicast Distributed Switching on the Line Card: Example

The following example shows how to maintain MDS on the line card:

```
enable
clear ip mds forwarding
exit
```

In this example, the MFIB table of the line card is cleared of entries and resynchronized with the RP.

Maintaining Multicast Distributed Switching on the Route Processor: Example

The following example shows how to maintain MDS on the RP:

```
enable
clear ip mroute *
clear ip pim interface count
exit
```

In this example, all entries are deleted from the IP multicast routing table and all line card counts or packet counts are cleared.

Additional References

The following sections provide references related to the Multicast Distributed Switching feature.

Related Documents

Related Topic	Document Title
Description of MDS commands	*Cisco IOS IP Switching Command Reference*
Overview of switching paths available on Cisco IOS devices	*Cisco IOS Switching Paths Overview*

Standards

Standard	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Command Reference

This feature uses no new or modified commands.

Feature Information for Configuring Multicast Distributed Switching

Table 1 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Releases 12.2(1) or 12.0(3)S or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the *Cisco IOS IP Switching Features Roadmap*.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 1 Feature Information for Configuring Multicast Distributed Switching

Feature Name	Releases	Feature Information
This table is intentionally left blank because no features were introduced or modified in Cisco IOS Release 12.2(1) or later. This table will be updated when feature information is added to this module.	—	—

Glossary

Cisco Express Forwarding—A Layer 3 switching technology. Cisco Express Forwarding can also refer to central Cisco Express Forwarding mode, one of two modes of Cisco Express Forwarding operation. Cisco Express Forwarding enables a Route Processor (RP) to perform express forwarding. Distributed Cisco Express Forwarding is the other mode of Cisco Express Forwarding operation

line card—A general term for an interface processor that can be used in various Cisco products. For example, a Versatile Interface Processor (VIP) is a line card for the Cisco 7500 series router.

MFIB—Multicast Forwarding Information Base. A protocol-independent multicast forwarding system that contains unique multicast forwarding entries for each source or group pair known in a given network. There is a separate MFIB for every logical network (VPN) in which the router is configured. Each MFIB entry resolves a given source or group pair to an incoming interface (IIF) for reverse forwarding (RPF) checking and an outgoing interface list (olist) for multicast forwarding.

RP—Route Processor. The processor module in the Cisco 7000 series routers that contains the CPU, system software, and most of the memory components that are used in the router. It is sometimes called a supervisory processor.

RSP—Route Switch Processor. Processor module in the Cisco 7000 series routers that integrates the functions of the Route Processor (RP) and the Switch processor (SP).

VIP—Versatile Interface Processor. An interface card used in Cisco 7000 and Cisco 7500 series routers. The VIP provides multilayer switching and runs Cisco IOS.