JUNOSe™ Software
for E-series™ Routing Platforms

Policy Management Configuration Guide

Release 9.0.x

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Part Number: 162-01848-00, Revision A00

JUNOSe™ Software for E-series™ Routing Platforms Policy Management Configuration Guide, Release 9.0.x
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Revision History
29 February 2008—Revision 1

The information in this document is current as of the date listed in the revision history.

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Table of Contents

About This Guide

This preface provides the following guidelines for using the *JUNOSe™ Software for E-series™ Routing Platforms Policy Management Configuration Guide*:

Objectives

This guide provides the information you need to configure policy management and packet mirroring on your E-series router.

An E-series router is shipped with the latest system software installed. If you need to install a future release or reinstall the system software, refer to the procedures in *JUNOSe System Basics Configuration Guide, Chapter 3, Installing JUNOSe Software*.

NOTE: If the information in the latest *JUNOSe Release Notes* differs from the information in this guide, follow the *JUNOSe Release Notes*.

Audience

This guide is intended for experienced system and network specialists working with E-series routers in an Internet access environment.

E-series Routers

Seven models of E-series routers are available:

- E120 router
- E320 router
- ERX-1440 router
- ERX-1410 router
- ERX-710 router
- ERX-705 router
- ERX-310 router

All models use the same software. For information about all models except the E120 router and the E320 router, see *ERX Hardware Guide, Chapter 1, ERX Overview*. For information about the E120 router and the E320 router, see *E120 and E320 Hardware Guide*, *Chapter 1*, *E120 and E320 Overview*.

In the E-series documentation, the term ERX-14xx models refers to both the ERX-1440 router and the ERX-1410 router. Similarly, the term ERX-7xx models refers to both the ERX-710 router and the ERX-705 router. The terms ERX-1440 router, ERX-1410 router, ERX-710 router, ERX-705 router, ERX-310 router, E120 router, and E320 router refer to the specific models.

Documentation Conventions

Table 1 defines notice icons used in this guide.

Table 1: Notice Icons

Icon	Meaning	Description
	Informational note	Indicates important features or instructions.
	Caution	Indicates a situation that might result in loss of data or hardware damage.
	Warning	Alerts you to the risk of personal injury.

Table 2 defines text conventions used in this guide and the syntax conventions used primarily in the *JUNOSe Command Reference Guide*. For more information about command syntax, see *JUNOSe System Basics Configuration Guide, Chapter 2, Command-Line Interface*.

Table 2: Text and Syntax Conventions

Convention	Description	Examples
Text Conventions		
Bold text like this	Represents commands and keywords in text.	■ Issue the **clock source** command. ■ Specify the keyword **exp-msg**.
Bold text like this	Represents text that the user must type.	host1(config)#**traffic class low-loss1**

`Fixed-width text like this`	Represents information as displayed on your terminal's screen.	`host1#show ip ospf 2`
		`Routing Process OSPF 2 with Router ID 5.5.0.250`
		`Router is an Area Border Router (ABR)`

Italic text like this	■ Emphasizes words. ■ Identifies variables. ■ Identifies chapter, appendix, and book names.	■ There are two levels of access, *user* and *privileged*. ■ *clusterId*, *ipAddress*. ■ *Appendix A*, *System Specifications*.
Plus sign (+) linking key names	Indicates that you must press two or more keys simultaneously.	Press Ctrl + b.
Syntax Conventions in the *Command Reference Guide*		
Plain text like this	Represents keywords.	terminal length
Italic text like this	Represents variables.	*mask*, *accessListName*
| (pipe symbol)	Represents a choice to select one keyword or variable to the left or right of this symbol. (The keyword or variable can be either optional or required.)	diagnostic | line
[ ] (brackets)	Represent optional keywords or variables.	[internal | external]
[ ]* (brackets and asterisk)	Represent optional keywords or variables that can be entered more than once.	[level1 | level2 | l1]*
{ } (braces)	Represent required keywords or variables.	{ permit | deny } { in | out } { *clusterId* | *ipAddress* }

Related E-series and JUNOSe Documentation

The E-series and JUNOSe documentation set consists of several hardware and software guides, which are available in electronic and printed formats.

E-series and JUNOSe Documents

Table 3 lists and describes the E-series and JUNOSe document set. For a complete list of abbreviations used in this document set, along with their spelled-out terms, see *JUNOSe System Basics Configuration Guide, Appendix A, Abbreviations and Acronyms*.

Table 3: Juniper Networks E-series and JUNOSe Technical Publications

Document	Description
E-series Hardware Documentation	
E120 and E320 Quick Start Guide	Shipped in the box with all new E120 and E320 routers. Provides the basic procedures to help you get the routers up and running quickly.
E120 and E320 Hardware Guide	Provides the necessary procedures for getting E120 routers and E320 routers operational, including information about: ■ Installing the chassis and modules ■ Connecting cables ■ Powering up the routers ■ Configuring the routers for management access ■ Troubleshooting common issues Describes switch route processor (SRP) modules, line modules, and I/O adapters (IOAs) available for E120 and E320 routers.
E120 and E320 Module Guide	Provides detailed specifications for line modules and IOAs in E120 and E320 routers, and information about the compatibility of these modules with JUNOSe software releases. Lists the layer 2 protocols, layer 3 protocols, and applications that line modules and their corresponding IOAs support. Provides module LED information.
E-series Installation Quick Start poster or *ERX Quick Start Guide*	Shipped in the box with all new ERX routers. Provides the basic procedures to help you get an ERX router up and running quickly.
ERX Hardware Guide	Provides the necessary procedures for getting ERX-14xx models, ERX-7xx models, and ERX-310 routers operational, including information about: ■ Installing the chassis and modules ■ Connecting cables ■ Powering up the routers ■ Configuring the routers for management access ■ Troubleshooting common issues Describes switch route processor (SRP) modules, line modules, and I/O modules available for the ERX routers.
ERX Module Guide	Provides detailed specifications for line modules and I/O modules in ERX-14xx models, ERX-7xx models, and ERX-310 routers, and information about the compatibility of these modules with JUNOSe software releases. Lists the layer 2 protocols, layer 3 protocols, and applications that line modules and their corresponding I/O modules support. Provides module LED information.

Table 3: Juniper Networks E-series and JUNOSe Technical Publications (continued)

Document	Description
ERX End-of-Life Module Guide	Provides an overview and description of ERX modules that are end-of-life (EOL) and can no longer be ordered for the following routers: ■ ERX-7xx models ■ ERX-14xx models ■ ERX-310 router
JUNOSe Software Guides	
JUNOSe System Basics Configuration Guide	Provides information about: ■ Planning and configuring your network ■ Using the command-line interface (CLI) ■ Installing JUNOSe software ■ Configuring the Simple Network Management Protocol (SNMP) ■ Managing the router and its modules, including the use of high availability (HA) for SRP redundancy ■ Configuring and running a unified in-service software upgrade (ISSU) ■ Configuring passwords and security ■ Configuring the router clock ■ Configuring virtual routers
JUNOSe Physical Layer Configuration Guide	Explains how to configure, test, and monitor physical layer interfaces.
JUNOSe Link Layer Configuration Guide	Explains how to configure and monitor static and dynamic link layer interfaces.
JUNOSe IP, IPv6, and IGP Configuration Guide	Explains how to configure and monitor IP, IPv6 and Neighbor Discovery, and interior gateway protocols (RIP, OSPF, and IS-IS).
JUNOSe IP Services Configuration Guide	Explains how to configure and monitor IP routing services. Topics include: ■ Routing policies ■ Firewalls ■ Network Address Translation (NAT) ■ J-Flow statistics ■ Bidirectional forwarding detection (BFD) ■ Internet Protocol Security (IPSec) ■ Access Node Control Protocol (ANCP), also known as Layer 2 Control (L2C) ■ Digital certificates ■ IP tunnels ■ Virtual Router Redundancy Protocol (VRRP) ■ Mobile IP home agent
JUNOSe Multicast Routing Configuration Guide	Explains how to configure and monitor IP multicast routing and IPv6 multicast routing. Topics include: ■ Internet Group Management Protocol (IGMP) ■ Protocol Independent Multicast (PIM) ■ Distance Vector Multicast Routing Protocol (DVMRP) ■ Multicast Listener Discovery (MLD)

Table 3: Juniper Networks E-series and JUNOSe Technical Publications (continued)

Document	Description
JUNOSe BGP and MPLS Configuration Guide	Explains how to configure and monitor: ■ Border Gateway Protocol (BGP) routing ■ Multiprotocol Label Switching (MPLS) and related applications ■ Layer 2 services over MPLS ■ Virtual private LAN service (VPLS) ■ Layer 2 virtual private networks (L2VPNs)
JUNOSe Policy Management Configuration Guide	Explains how to configure, manage, and monitor customized policy rules for packet classification, forwarding, filtering, and flow rates. Also describes the packet mirroring feature, which uses secure policies.
JUNOSe Quality of Service Configuration Guide	Explains how to configure quality of service (QoS) features to queue, schedule, and monitor traffic flow. These features include: ■ Traffic classes and traffic-class groups ■ Drop, queue, QoS, and scheduler profiles ■ QoS parameters ■ Statistics
JUNOSe Broadband Access Configuration Guide	Explains how to configure and monitor a remote access environment, which can include the following features: ■ Authentication, authorization, and accounting (AAA) ■ Dynamic Host Configuration Protocol (DHCP) ■ Remote Authentication Dial-In User Service (RADIUS) ■ Terminal Access Controller Access Control System (TACACS+) ■ Layer 2 Tunneling Protocol (L2TP) ■ Subscriber management
JUNOSe System Event Logging Reference Guide	Describes the JUNOSe system logging feature and describes how to use the CLI to monitor your system's log configuration and system events.
JUNOSe Command Reference Guide A to M; JUNOSe Command Reference Guide N to Z	Together constitute the *JUNOSe Command Reference Guide*. Contain important information about commands implemented in the system software. Use to look up: ■ Descriptions of commands and command parameters ■ Command syntax ■ A command's related mode ■ Starting with JUNOSe Release 7.1.0, a history of when a command, its keywords, and its variables were introduced or added Use with the JUNOSe configuration guides.
JUNOSe Comprehensive Index	Provides a complete index of the JUNOSe software documentation set.
JUNOSe Glossary	Provides definitions for terms used in JUNOSe technical documentation.
Release Notes	
JUNOSe Release Notes	Provide the latest information about features, changes, known problems, resolved problems, and system maximum values. If the information in the *Release Notes* differs from the information found in the documentation set, follow the *Release Notes*. Release notes are included on the corresponding software CD and are available on the Web.

JUNOSe Configuration Guides

JUNOSe software configuration guides use a bottom-up approach to describe the relationship of layers, protocols, and interfaces in the configuration process. For more information, see *Layered Approach* in *JUNOSe System Basics Configuration Guide, Chapter 1, Planning Your Network*.

The chapters in JUNOSe software configuration guides typically include the following topics:

- Conceptual and overview information
- Information you need to know or tasks you need to perform before you begin
- Platform-specific issues you need to take into consideration
- Applicable references, such as RFCs and IETF draft documents, about the protocols and features supported by the router
- Required and optional tasks, as step-by-step procedures
- Descriptions and examples of the commands you use
- Illustrations of network topologies
- Examples of command sequences for configuration, testing, and monitoring activities
- Sample displays that result when you issue the **show** command

Obtaining Documentation

To obtain the most current version of all Juniper Networks technical documentation, see the products documentation page on the Juniper Networks Web site at http://www.juniper.net/.

To order printed copies of this manual and other Juniper Networks technical documents or to order a documentation CD, which contains this manual, contact your sales representative.

Copies of the Management Information Bases (MIBs) available in a software release are included on the software CDs and at http://www.juniper.net/.

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- Document name
- Document part number
- Page number
- Software release version

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- **JTAC Policies**—For a complete understanding of our JTAC procedures and policies, review the *JTAC User Guide* located at http://www.juniper.net/customers/support/downloads/710059.pdf
- **Product Warranties**—For product warranty information, visit http://www.juniper.net/support/warranty/
- **JTAC Hours of Operation**—The JTAC centers have resources available 24 hours a day, 7 days a week, 365 days a year.

Self-Help Online Tools and Resources

For quick and easy problem resolution, Juniper Networks has designed an online self-service portal called the Customer Support Center (CSC) that provides you with the following features:

- Find CSC offerings: http://www.juniper.net/customers/support/
- Search for known bugs: http://www2.juniper.net/kb/
- Find product documentation: http://www.juniper.net/techpubs/
- Find solutions and answer questions using our Knowledge Base: http://kb.juniper.net/
- Download the latest versions of software and review release notes: http://www.juniper.net/customers/csc/software/

- Search technical bulletins for relevant hardware and software notifications: https://www.juniper.net/alerts/
- Join and participate in the Juniper Networks Community Forum: http://www.juniper.net/company/communities/
- Open a case online in the CSC Case Manager: http://www.juniper.net/cm/

To verify service entitlement by product serial number, use our Serial Number Entitlement (SNE) Tool located at https://tools.juniper.net/SerialNumberEntitlementSearch/

Opening a Case with JTAC

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- Use the Case Manager tool in the CSC at http://www.juniper.net/cm/
- Call 1-888-314-JTAC (1-888-314-5822 – toll free in the USA, Canada, and Mexico)

For international or direct-dial options in countries without toll-free numbers, visit http://www.juniper.net/support/requesting-support.html

Part 1

Policy Management

Chapter 1

Managing Policies on the E-series Router

This chapter discusses the following topics:

Policy Management Overview

This chapter introduces policy-based routing management on E-series routers. Policy management enables you to configure, manage, and monitor policies that selectively cause packets to take different paths without requiring a routing table lookup. The JUNOSe software's packet mirroring feature uses secure policies.

Policy management enables network service providers to configure services that customize the treatment of individual packet flows received on a subscriber's interface. The main tool for implementing policy management is a policy list. A policy list is a set of rules, each of which specifies a policy action. A rule is a policy action optionally combined with a classification.

Packets are sorted at ingress or egress into packet flows based on attributes defined in classifier control lists (CLACLs). You can apply policy lists to packets arriving and leaving an interface. You can use policy management on ATM, Frame Relay, generic routing encapsulation (GRE), IP, IPv6, Layer 2 Tunneling Protocol (L2TP), Multiprotocol Label Switching (MPLS), and virtual local area network (VLAN) traffic.

Policy management provides:

- Policy routing—Predefines a classified packet flow to a destination port or IP address. The router does not perform a routing table lookup on the packet. This provides superior performance for real-time applications.

- Bandwidth management—Rate-limits a classified packet flow at ingress to enforce ingress data rates below the physical line rate of a port, A rate-limit profile with a policy rate-limit profile rule provides this capability. You can construct policies to provide rate limiting for individual packet flows or for the aggregate of multiple packet flows. E-series router rate limits are calculated based on the layer 2 packet size. To configure rate limiting, you first create a rate-limit profile, which is a set of bandwidth attributes and associated actions. You next create a policy list with a rule that has rate limit as the action and associate a rate-limit profile with this rule. You can configure rate-limit profiles to provide a variety of services, including tiered bandwidth service where traffic conforming to configured bandwidth levels is treated differently than traffic that exceeds the configured values, and a hard-limit service where a fixed bandwidth limit is applied to a traffic flow. Finally, you can configure rate-limit profiles to provide a TCP-friendly rate-limiting service that works in conjunction with TCP's native flow-control functionality.

- Security—Provides a level of network security by using policy rules that selectively forward or filter packet flows. You can use a filter rule to stop a denial-of-service attack. You can use secure policies to mirror packets and send them to an analyzer.

- RADIUS policy support—Enables you to create and attach a policy to an interface through RADIUS.

- Packet tagging—Enables the traffic-class rule in policies to tag a packet flow so that the Quality of Service (QoS) application can provide traffic-class queuing. Policies can perform both in-band and out-of-band packet tagging.

- Packet forwarding—Allows forwarding of packets in a packet flow.

- Packet filtering—Drops packets in a packet flow.

- Packet mirroring—Uses secure policies to mirror packets and send them to an analyzer.

- Packet logging—Logs packets in a packet flow.

Policy management gives you the CLI tools to build databases, which can then be drawn from to implement a policy. Each database contains global traffic specifications. When building a policy, you specify input from one or more of these databases and then attach the policy to an interface. By combining the information from the various databases into policies, you can deploy a wide variety of services.

Description of a Policy

A policy is a condition and an action that is attached to an interface. The condition and action cause the router to handle the packets passing through the interface in a certain way. A policy can be attached to IP interfaces and certain layer 2 interfaces such as Frame Relay, L2TP, MPLS, and VLAN interfaces. The policies do not need to be the same in both directions.

Packets are sorted at ingress or egress into packet flows based on attributes defined in classifier control lists. Policy lists contain rules that associate actions with these CLACLs. A rule is a policy action optionally combined with a classification.

When packets arrive on an interface, you can have a policy evaluate a condition before the normal route lookup; this kind of policy is known as an *input policy*. You can also have conditions evaluated after a route lookup; this kind of policy is known as a *secondary input policy*. You can use secondary input policies to defeat denial-of-service attacks directed at a router's local interface or to protect a router from being overwhelmed by legitimate local traffic. If you have a policy applied to packets before they leave an interface, this is known as an *output policy*.

Classification is the process of taking a single data stream in and sorting it into multiple output substreams. The classifier engine on an E-series router is a combination of PowerPC processors, working with a Field Programmable Gate Array (FPGA) for a hardware assist.

In the Differentiated Services (DiffServ) architecture, two basic types of classifiers exist. The first classifier type is a multifield (MF) classifier, which examines multiple fields in the IP datagram header to determine the service class to which a packet belongs. The second type of classifier is a behavior aggregate (BA) classifier, which examines a single field in an IP datagram header and assigns the packet to a service class based on what it finds.

There are two categories of hardware classifiers, depending on the type of line module being used. ES2 4G LM, ES2 10G Uplink LM, ES2 10G LM, OC48/STM16, GE-2, and GE-HDE line modules support content-addressable memory (CAM) hardware classifiers—all other line modules support FPGA hardware classifiers.

The maximum number of policies that you can attach to interfaces on an E-series router depends on the classifier entries that make up the policy and the number of attachment resources available on the interface. JUNOSe software allocates interface attachment resources when you attach policies to interfaces. E-series routers support software and hardware classifiers. A policy can be made up of any combination of software and hardware classifiers.

Platform Considerations

Policy services are supported on all E-series routers.

For information about the modules supported on E-series routers:

- See the *ERX Module Guide* for modules supported on ERX-7xx models, ERX-14xx models, and the ERX-310 router.
- See the *E120 and E320 Module Guide* for modules supported on the E120 router and the E320 router.

References

For more information about policy management, see the following resources:

- RFC 2474—Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers (December 1998)
- RFC 2475—An Architecture for Differentiated Services (December 1998)
- RFC 2697—A Single Rate Three Color Marker (September 1999)
- RFC 2698—A Two Rate Three Color Marker (September 1999)
- RFC 3198—Terminology for Policy-Based Management (November 2001)

Policy Management Configuration Tasks

Perform the required tasks and also any optional tasks that you need for your policy management configuration:

1. Create a CLACL (optional).

   See *Chapter 2, Creating Classifier Control Lists for Policies*

2. Create a rate-limit profile (optional).

   See *Chapter 5, Creating Rate-Limit Profiles*

3. Create a policy list.

   See *Chapter 3, Creating Policy Lists*

4. Create a classifier group.

   See *Chapter 4, Creating Classifier Groups and Policy Rules*

5. Create one or more policy rules within the classifier group.

   See *Chapter 4, Creating Classifier Groups and Policy Rules*

6. Apply a policy list to an interface or profile.

   See *Chapter 4, Creating Classifier Groups and Policy Rules*

Chapter 2

Creating Classifier Control Lists for Policies

This chapter provides information for configuring policy-based routing management on E-series routers. The chapter discusses the following topics:

Classifier Control Lists Overview

Classifier control lists (CLACLs) specify the criteria by which the router defines a packet flow. Table 4 lists the criteria that you can use to create CLACLs for different types of traffic flows.

Table 4: CLACL Criteria

Type of CLACL	Criteria
ATM	■ CLP ■ Color ■ Traffic class ■ User packet class
Frame Relay	■ Color ■ Mark discard eligibility (DE) bit ■ Traffic class ■ User packet class
GRE	■ Color ■ Traffic class ■ Type-of-service (ToS) byte ■ User packet class
IP	■ Color ■ Destination IP address ■ Destination port ■ Destination route class ■ Internet Control Message Protocol (ICMP) ■ Internet Gateway Management Protocol (IGMP) ■ IP flags ■ IP fragmentation offset ■ Locally destined traffic ■ Protocol ■ Source IP address ■ Source port ■ Source route class ■ Transmission Control Protocol (TCP) ■ Traffic class ■ Type-of-service (ToS) byte ■ User Datagram Protocol (UDP) ■ User packet class

Table 4: CLACL Criteria (continued)

Type of CLACL	Criteria
IPv6	■ Color ■ Destination IPv6 address ■ Destination port ■ Destination route class ■ Internet Control Message Protocol version 6 (ICMPv6) ■ IPv6 traffic class ■ Locally destined traffic ■ Multicast Listener Discovery (MLD) ■ Next header ■ Source IPv6 address ■ Source port ■ Source route class ■ Traffic class ■ Transmission Control Protocol (TCP) ■ User Datagram Protocol (UDP) ■ User packet class
L2TP	■ Color ■ Traffic class ■ User packet class
MPLS	■ Color ■ Mark experimental (EXP) bit ■ Traffic class ■ User packet class
VLAN	■ Color ■ Traffic class ■ User packet class ■ User priority

You configure CLACLs with a name and then values to match in the IP datagram header. A CLACL does not include an action: actions take place when a match is included in a policy list.

NOTE: Do not use the asterisk (*) for the name of a classifier list. The asterisk is used as a wildcard for the **classifier-group** command.

NOTE: If you do not specify one of the **frame-relay**, **gre-tunnel**, **ip, ipv6, l2tp, mpls,** or **vlan** keywords, the router creates an IP classifier list. This version of the command has been deprecated and may be removed in a future release.

Related Topics

- For information about the hardware and software CLACLs that are supported for each interface type, see *Chapter 8, Policy Resources*.
- For information about monitoring Classifier Lists, see *Chapter 9, Monitoring Policy Management*.

Creating or Modifying Classifier Control Lists for ATM Policy Lists

You can create or modify a classifier control list that can be used only in ATM policy lists.

- Issue the **atm classifier-list** command:

  host1(config)#**atm classifier-list atmclassifier color red user-packet-class 10 clp 1**

Related Topics

- **atm classifier-list** command

Creating or Modifying Classifier Control Lists for Frame-Relay Policy Lists

You can create or modify a classifier control list that can be used only in Frame Relay policy lists.

- Issue the **frame-relay classifier-list** command.;

  host1(config)#**frame-relay classifier-list frclassifier color red user-packet-class 10 de-bit 1**

Related Topics

- **frame-relay classifier-list** command

Creating or Modifying Classifier Control Lists for GRE Tunnel Policy Lists

You can create or modify a classifier control list that can be used only in GRE tunnel policy lists.

- Issue the **gre-tunnel classifier-list** command:

  host1(config)#**gre-tunnel classifier-list greClassifier50 color yellow user-packet-class 7 dsfield 40**

Related Topics

- **gre-tunnel classifier-list** command

Creating or Modifying Classifier Control Lists for IP Policy Lists

You can create or modify a classifier control list that can be used only in IP policy lists.The behavior of multiple-element classifier-list classification is the logical OR of the elements in the CLACL.

- Issue the **ip classifier-list** command to match all packets that have a source IP address of 192.168.30.100 or have a destination IP address of 192.168.30.200:

  host1(config)#**ip classifier-list boston5 ip host 192.168.30.100 any**
  host1(config)#**ip classifier-list boston5 ip any host 192.168.30.200**

Related Topics

- ip classifier-list command

Setting Up an IP Classifier Control List to Accept Traffic from All Sources

You can set up a CLACL to accept IP traffic from all source addresses on the subnet.

- Issue the **ip classifier-list** command:

  host1(config)#**ip classifier-list XYZCorpPermit ip 192.168.0.0 0.0.255.255 any**

Classifying IP Traffic Based on Source and Destination Addresses

You can classify traffic based on source and destination addresses, You can specify the address as a host address, a subnet, or a wildcard. If you specify the address as a subnet, the mask, in binary notation, must be a series of contiguous zeros, followed by a series of contiguous ones. The **any** keyword is the address wildcard, matching traffic for any address.

- Issue the **ip classifier-list** command to classify traffic on any source or destination address:

  host1(config)#**ip classifier-list YourListName ip any any**
  host1(config)#**ip classifier-list YourListName ip host 10.10.10.10 any**
  host1(config)#**ip classifier-list YourListName ip 10.10.0.0 0.0.255.255 host 10.10.10.2**

Using IP Classifier Control Lists to Match Route Class Values

You can set up classifier control lists to match route-class values. In this example, svale20 matches the source address lookup route-class value of 1, svale30 matches the destination address lookup route-class value of 1 and a ToS byte value of 10, svale40 matches the source address lookup route-class value of 1 and the packets destined to a local interface, and west20 matches the source address lookup route-class value of 1 and packets that are not destined for a local interface (packets destined for remote interfaces).

- Issue the **ip classifier-list** command:

  host1(config)#**ip classifier-list svale20 source-route-class 1 ip any any**
  host1(config)#**ip classifier-list svale30 destination-route-class 1 ip any any tos 10**

host1(config)#**ip classifier-list svale40 source-route-class 1 local true ip any any**
host1(config)#**ip classifier-list west25 source-route-class 1 local false ip any any**

Creating IP Classifier Control Lists for TCP and UDP Ports

You can specify a single TCP or UDP port or a range of ports, where packets are matched with source address 198.168.30.100 and UDP source port numbers in the range 1–10.

- Issue the **ip classifier-list** command to create a CLACL on a UDP host:

  host1(config)#**ip classifier-list YourListName udp host 192.168.30.100 range 1 10 any**

  To create a CLACL that matches all traffic on UDP source ports greater than 100:

  host1(config)#**ip classifier-list XYZCorpUdp udp any gt 100 172.17.2.1 0.0.255.255**

  To match a non-TCP packet originating from IP address 172.28.100.52:

  host1(config)#**ip classifier-list YourListName not tcp host 172.28.100.52 any**

  To specify a single TCP or UDP port or range of ports, an ICMP code and optional type, or an IGMP type, which matches packets with source address 198.168.30.100 and ICMP type 2 and code 10:

  host1(config)#**ip classifier-list YourListName icmp host 192.168.30.100 any 2 10**

Creating an IP Classifier Control List That Matches the ToS Byte

You can create an IP CLACL that matches the ToS byte in the IP header.

- Issue the **ip classifier-list** command using the **tos** keyword.

  host1(config)#**ip classifier-list tos128 ip any any tos 128**
  host1(config)#**ip classifier-list low-drop-prec ip any any dsfield 10**
  host1(config)#**ip classifier-list priority ip any any precedence 1**

Creating an IP Classifier Control List That Filters ICMP Echo Requests

You can create a CLACL that filters all ICMP echo requests headed toward an access link under a denial-of-service attack.

- Issue the **ip classifier-list** command:

  host1(config)#**ip classifier-list XYZCorpIcmpEchoReqs icmp any any 8 0**

  host1(config)#**ip classifier-list XYZCorpIgmpType1 igmp any any 1**

Creating IP Classifier Control Lists That Use TCP or IP Flags

You can create CLACLs that use TCP or IP flags. For both IP flags and TCP flags, if you specify only a single flag, the logical equation does not require quotation marks.

- Issue the **ip classifier-list** command with the **tcp-flags** keyword and a logical equation (a quotation-enclosed string using ! for NOT, & for AND) to match one or more of the **ack, fin, psh, rst, syn,** or **urg** TCP flags:

  host1(config)#**ip classifier-list telnetConnects tcp 192.168.10.0 0.0.0.255 host 10.10.10.10 eq 23 tcp-flags "syn & !ack"**

- Issue the **ip classifier-list** command with the **ip-flags** keyword and a logical equation (a quotation-enclosed string using ! for NOT, & for AND) to match one or more of the **dont-fragment**, **more-fragments**,, or **reserved** IP flags:

  host1(config)#**ip classifier-list dontFragment ip any any ip-flags "dont-fragment"**

Creating IP Classifier Control Lists That Match the IP Fragmentation Offset

You can create CLACLs that match the IP fragmentation offset.

- Issue the **ip classifier-list** command with the **ip-frag-offset** keyword and the **eq** or **gt** operator to match an IP fragmentation offset equal to 0, 1, or greater than 1:

  host1(config)#**ip classifier-list fragOffsetAttack ip any host 10.10.10.10 ip-frag-offset eq 1**
  host1(config)#**ip policy-list dosProtect**
  host1(config-policy-list)#**filter classifier-group fragOffsetAttack**
  host1(config-policy-list)#**forward**

Creating or Modifying Classifier Control Lists for IPv6 Policy Lists

You can create or modify a classifier control list that can be used only in IPv6 policy lists.

- Issue the **ipv6 classifier-list** command:

  host1(config)#**ipv6 classifier-list ipv6classifier color red user-packet-class 5 tcfield 10**

  host1(config)#**ipv6 classifier-list YourListName udp destination-port eq 75**

  host1(config)#**ipv6 classifier-list telnetConnects tcp destination-port eq 23 tcp-flags "syn & !ack"**

  host1(config)#**ipv6 classifier-list listname icmpv6 icmp-type 3 icmp-code 6**

  host1(config)#**ipv6 classifier-list svale20 source-route-class 1**
  host1(config)#**ipv6 classifier-list svale30 destination-route-class 1 tcfield 10**
  host1(config)#**ipv6 classifier-list svale40 source-route-class 1 local true**
  host1(config)#**ipv6 classifier-list west25 source-route-class 1 local false**

  host1(config)#**ipv6 classifier-list YourClaclList source-host 2001:db8:1::8001 destination-address 2001:db8:3::/48**

Related Topics

- ipv6 classifier-list command

Creating or Modifying Classifier Control Lists for L2TP Policy Lists

You can create or modify a classifier control list that can be used only in L2TP policy lists.

- Issue the **l2tp classifier-list** command:

  host1(config)#**l2tp classifier-list l2tpclassifier color red user-packet-class 7**

Related Topics

- l2tp classifier-list command

Creating or Modifying Classifier Control Lists for MPLS Policy Lists

You can create or modify a classifier control list that can be used only in MPLS policy lists.

- Issue the **mpls classifier-list** command:

  host1(config)#**mpls classifier-list mplsClass user-packet-class 10 exp-bits 3 exp-mask 5**

Related Topics

- mpls classifier-list command

Creating or Modifying Classifier Control Lists for VLAN Policy Lists

You can create or modify a classifier control list that can be used only in VLAN policy lists.

- Issue the **vlan classifier-list** command:

  host1(config)#**vlan classifier-list lowLatencyLowDrop user-priority 7**
  host1(config)#**vlan classifier-list lowLatencyLowDrop user-priority 6**
  host1(config)#**vlan classifier-list lowLatency user-priority 5**
  host1(config)#**vlan classifier-list excellentEffort user-priority 4**
  host1(config)#**vlan classifier-list bestEffort user-priority 3**
  host1(config)#**vlan classifier-list bestEffort user-priority 2**
  host1(config)#**vlan classifier-list bestEffort user-priority 1**
  host1(config)#**vlan classifier-list bestEffort user-priority 0**

Related Topics

- vlan classifier-list command

Chapter 3

Creating Policy Lists

This chapter provides information for configuring policy lists on E-series routers. The chapter discusses the following topics:

Policy Lists Overview

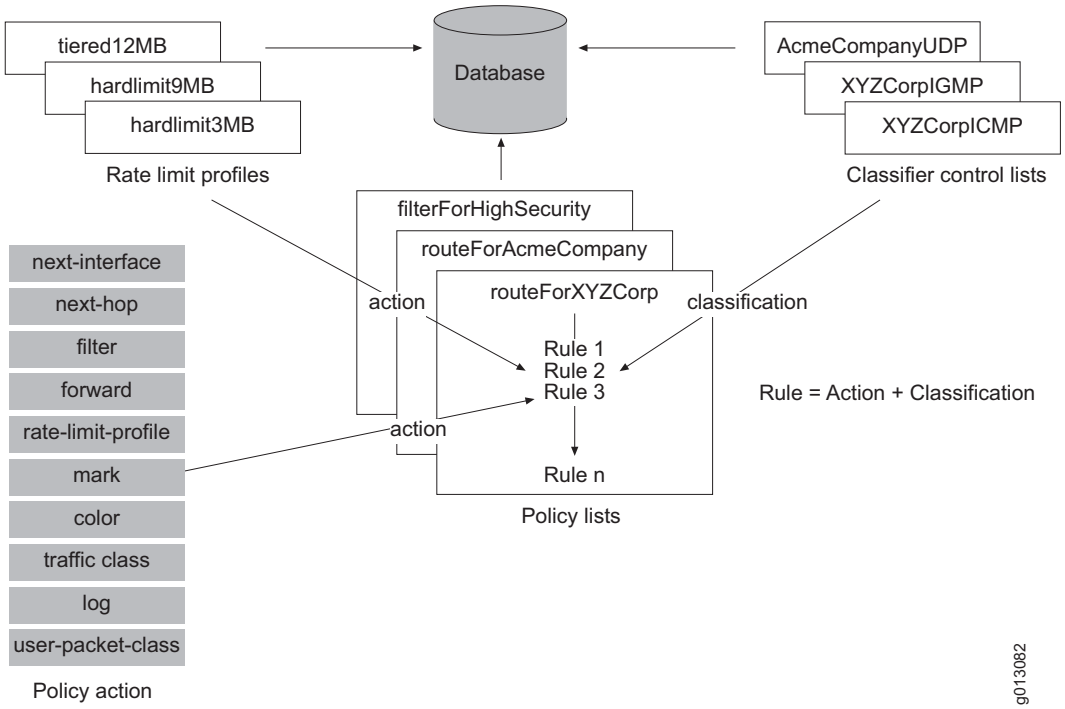
You create a policy rule by specifying a policy action within a classifier group that references a CLACL. These rules become part of a policy list that you can attach to an interface as either an input policy, secondary-input policy, or output policy. The router applies the rules in the attached policy list to the packets traversing that interface.

You can apply policy lists to packets:

- Arriving at an interface (input policy); on IP and IPv6 interfaces the packets arrive before route lookup
- Arriving at the interface, but after route lookup (secondary input policy); secondary input policies are supported only on IP and IPv6 interfaces
- Leaving an interface (output policy)

Figure 1 shows how a sample IP policy list is constructed.

Figure 1: Constructing an IP Policy List



You can create a policy list with an unlimited number of classifier groups, each containing an unlimited number of rules. These rules can reference up to 512 classifier entries.

If you enter a **policy-list** command and then enter **exit**, the router creates a policy list with no rules. If the router does not find any rules in a policy, it inserts a default filter rule. Attaching this policy list to an interface filters all packets on that interface.

NOTE: If you do not specify one of the **frame-relay**, **gre-tunnel**, **ip, ipv6, l2tp, mpls,** or **vlan** keywords, the router creates an IP policy list. This version of the command has been deprecated and may be removed in a future release.

You can create policy lists for ATM, Frame Relay, IP, IPv6, GRE tunnels, L2TP, MPLS, and VLANs.

NOTE: Commands that you issue in Policy Configuration mode do not take effect until you exit from that mode.

Related Topics

- Policy Lists Overview on page 17
- *Chapter 9, Monitoring Policy Management*

Creating Policy Lists for ATM

In the following example, you create two policies: one for CBR traffic and one for UBR traffic. One policy is attached to an interface that contains CBR traffic and the other to an interface that contains UBR traffic.

1. Create a CBR policy list.

   ```
   host1(config)#atm policy-list polCbr
   host1(config-policy-list)#
   ```

2. Create the classification group and assign a strict priority traffic class and color green.

   ```
   host1(config-policy-list)#classifier-group *
   host1(config-policy-list-classifier-group)#traffic-class strict-priority
   host1(config-policy-list-classifier-group)#color green
   ```

3. Exit Policy List Configuration mode to save the configuration.

   ```
   host1(config-policy-list-classifier-group)#exit
   host1(config-policy-list)#exit
   host1(config)#
   ```

4. Create a UBR policy that maps to the strict best-effort traffic class and color red.

   ```
   host1(config)#atm policy-list polUbr
   host1(config-policy-list)#classifier-group *
   host1(config-policy-list-classifier-group)#traffic-class best-effort
   host1(config-policy-list-classifier-group)#color red
   ```

5. Exit Policy List Configuration mode to save the configuration.

   ```
   host1(config-policy-list-classifier-group)#exit
   host1(config-policy-list)#exit
   host1(config)#
   ```

6. Attach the policies to ATM subinterfaces.

   ```
   host1(config)#interface atm 0/0.100
   host1(config-if)#atm policy input polUbr statistics enabled
   host1(config-if)#exit
   host1(config)#interface atm 0/0.101
   host1(config-if)#atm policy input polCbr statistics enabled
   host1(config-if)#exit
   ```

7. Display the policy lists.

   ```
   host1#show atm subinterface atm 0/0.100

   Circuit                  Interface
    Interface  ATM-Prot VCD VPI VCI  Type   Encap MTU  Status   Type
   ---------- -------- --- --- --- ------- ----- ---- ------ ---------
   ATM 0/0.100 RFC-1483 100   0 100 PVC     SNAP  9180 up     Static

   Auto configure status         : static
   Auto configure interface(s)   : none
   ```

```
Detected 1483 encapsulation   : none
Detected dynamic interface    : none
Interface types in lockout    : none

Assigned profile (IP)         : none assigned
Assigned profile (BridgedEnet): none assigned
Assigned profile (PPP)        : none assigned
Assigned profile (PPPoE)      : none assigned
Assigned profile (any)        : none assigned

SNMP trap link-status: disabled

InPackets:                0
InBytes:                  0
OutPackets:               0
OutBytes:                 0
InErrors:                 0
OutErrors:                0
InPacketDiscards:         0
InPacketsUnknownProtocol: 0
OutDiscards:              0
ATM policy input polUbr
  Statistics are disabled
1 interface(s) found

host1#show atm subinterface atm 0/0.101

                                  Circuit                   Interface
 Interface  ATM-Prot VCD VPI VCI  Type   Encap MTU  Status   Type
----------- -------- --- --- --- ------- ----- ---- ------ ---------
ATM 0/0.101 RFC-1483 101   0 101 PVC     SNAP  9180 up     Static

Auto configure status         : static
Auto configure interface(s)   : none
Detected 1483 encapsulation   : none
Detected dynamic interface    : none
Interface types in lockout    : none

Assigned profile (IP)         : none assigned
Assigned profile (BridgedEnet): none assigned
Assigned profile (PPP)        : none assigned
Assigned profile (PPPoE)      : none assigned
Assigned profile (any)        : none assigned

SNMP trap link-status: disabled

InPackets:                0
InBytes:                  0
OutPackets:               0
OutBytes:                 0
InErrors:                 0
OutErrors:                0
InPacketDiscards:         0
InPacketsUnknownProtocol: 0
OutDiscards:              0
ATM policy input polCbr
  classifier-group *
    3096 packets, 377678 bytes
    traffic-class best-effort
    color green
1 interface(s) found
```

Related Topics

- **atm policy-list** command

Creating Policy Lists for Frame Relay

The following example creates a Frame Relay policy that on egress marks the DE bit to 1, and on ingress colors frames with a DE bit of 1 as red.

1. Create the policy list used to mark egress traffic, then create the classifier group for packets conforming to CLACL frMatchDeSet. Add a rule that marks the DE bit as 1.

   host1(config)#**frame-relay policy-list frOutputPolicy**
   host1(config-policy-list)#**classifier-group frMatchDeSet**
   host1(config-policy-list-classifier-group)#**mark-de 1**
   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**exit**

2. Create the policy list used for the ingress traffic. and create the classifier group conforming to CLACL frMatchDeSet. Add a rule that colors the ingress traffic.

   host1(config)#**frame-relay policy-list frInputPolicy**
   host1(config-policy-list)#**classifier-group frGroupA**
   host1(config-policy-list-classifier-group)#**color red**
   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**exit**

3. Apply the policy lists.

   host1(config)#**interface serial 5/0:1/1.1**
   host1(config-subif)#**frame-relay policy output frOutputPolicy statistics enabled**
   host1(config-subif)#**ip address 10.0.0.1 255.255.255.0**
   host1(config-subif)#**exit**
   host1(config)#**interface serial 5/1:1/1.1**
   host1(config-subif)#**frame-relay policy input frInputPolicy statistics enabled**
   host1(config-subif)#**exit**

4. Display interface information to view the applied policies.

```
host1#show frame-relay subinterface

Frame relay sub-interface SERIAL5/0:1/1.1, status is up
Number of sub-interface down transitions is 0
Time since last status change 03:04:59
No baseline has been set
  In bytes: 660                    Out bytes: 660
  In frames: 5                     Out frames: 5
  In errors: 0                     Out errors: 0
  In discards: 0                   Out discards: 0
  In unknown protos: 0
Frame relay policy output frOutputPolicy
  classifier-group frGroupA entry 1
     5 packets, 640 bytes
     mark-de 1
Frame relay sub-interface SERIAL5/1:1/1.1, status is up
Number of sub-interface down transitions is 0
Time since last status change 03:05:09
```

```
No baseline has been set
  In bytes: 660                    Out bytes: 660
  In frames: 5                     Out frames: 5
  In errors: 0                     Out errors: 0
  In discards: 0                   Out discards: 0
  In unknown protos: 0
Frame relay policy input frInputPolicy
  classifier-group frMatchDeSet entry 1
     5 packets, 660 bytes
     color red
```

5. Display the classifier list.

```
host1#show classifier-list detailed

                        Classifier Control List Table
                        ---------- ------- ---- -----
Frame relay Classifier Control List frMatchDeSet
   Reference count:      1
   Entry count:          1

   Classifier-List frMatchDeSet Entry 1
      DE Bit:                    1
```

6. Display the policy lists.

```
host1#show policy-list

                                  Policy Table
                                  ------ -----

Frame relay Policy frOutputPolicy
   Administrative state: enable
   Reference count:      0
   Classifier control list: frMatchDeSet, precedence 100
      mark-de 1

Frame relay Policy frInputPolicy
   Administrative state: enable
   Reference count:      0
   Classifier control list: frGroupA, precedence 100
     color red
```

Related Topics

- **frame-relay policy-list** command

Creating Policy Lists for GRE Tunnels

The following example creates a GRE tunnel policy list named routeGre50. For information about creating the CLACL used in this example, see the previous sections.

1. Create the policy list routeGre50.

   host1(config)#**gre-tunnel policy-list routeGre50**

2. Create the classification group for the CLACL named gre8 and assign a precedence of 150 to it.

   host1(config-policy-list)#**classifier-group gre8 precedence 150**
   host1(config-policy-list-classifier-group)#

3. Add two rules for traffic based on the CLACL named gre8: one rule to color packets as red, and a second rule that specifies the ToS DS field value to be assigned to the packets.

   host1(config-policy-list-classifier-group)#**color red**
   host1(config-policy-list-classifier-group)#**mark dsfield 20**
   host1(config-policy-list-classifier-group)#

4. Exit Policy List Configuration mode to save the configuration.

   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**exit**
   host1(config)#

5. Display the policy list.

```
host1#show policy-list routeGre50

                                  Policy Table
                                  ------ -----
GRE Tunnel Policy routeGre50
   Administrative state: enable
   Reference count:      0
   Classifier control list: gre8, precedence 150
      color red
      mark dsfield 20
```

Related Topics

- **gre-tunnel policy-list** command

Creating Policy Lists for IP

The following example creates an IP policy list named routeForABCCorp. For information about creating the CLACLs and rate-limit profile used in this example, see the previous sections.

1. Create the policy list routeForABCCorp.

   host1(config)#**ip policy-list routeForABCCorp**
   host1(config-policy-list)#

2. Create the classification group for the CLACL named ipCLACL10 and assign the precedence to the classification group.

   host1(config-policy-list)#**classifier-group ipCLACL10 precedence 75**
   host1(config-policy-list-classifier-group)#

3. Add a rule that specifies a group of forwarding solutions based on classifier list ipCLACL10.

   host1(config-policy-list-classifier-group)#**forward next-hop 192.0.2.12 order 10**
   host1(config-policy-list-classifier-group)#**forward next-hop 192.0.100.109 order 20**
   host1(config-policy-list-classifier-group)#**forward next-hop 192.120.17.5 order 30**
   host1(config-policy-list-classifier-group)#**forward interface ip 3/1 order 40**

4. Add a rule that sets a ToS byte value of 125 for packets based on classifier list ipCLACL10.

   host1(config-policy-list-classifier-group)#**mark tos 125**

5. Add a rule that uses rate-limit profile ipRLP25.

   host1(config-policy-list-classifier-group)#**rate-limit-profile ipRLP25**

6. Exit Classifier Group Configuration mode for ipCLACL10, then create a new classification group for classifier list ipCLACL20. Add a rule that filters packets based on classifier list ipCLACL20.

   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**classifier-group ipCLACL20 precedence 125**
   host1(config-policy-list-classifier-group)#**filter**

7. Exit Policy List Configuration mode to save the configuration.

   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**exit**
   host1(config)#

8. Display the policy list.

```
host1#show policy-list routeForABCCorp

                                    Policy Table
                                    ------ -----
IP Policy routeForABCCorp
   Administrative state: enable
   Reference count:      0
   Classifier control list: ipCLACL10, precedence 75
      forward
         Virtual-router: default
         List:
           next-hop 192.0.2.12, order 10, rule 2 (active)
           next-hop 192.0.100.109, order 20, rule 3 (reachable)
           next-hop 192.120.17.5, order 30, rule 4 (reachable)
           interface ip3/1, order 40, rule 5
      mark tos 125
      rate-limit-profile ipRLP25
   Classifier control list: ipCLACL20, precedence 125
      filter
```

Related Topics

- **ip policy-list** command

Creating Policy Lists for IPv6

The following example creates an IPv6 policy list named routeForIPv6. For information about creating the CLACL used in this example, see the previous sections.

1. Create the policy list routeForIPv6.

```
host1(config)#ipv6 policy-list routeForIPv6
host1(config-policy-list)#
```

2. Create the classification group for the CLACL named ipv6tc67 and assign the precedence to the classification group.

```
host1(config-policy-list)#classifier-group ipv6tc67 precedence 75
host1(config-policy-list-classifier-group)#
```

3. Add a rule to color packets as red, and a second rule that sets the traffic class field of the packets to 7.

```
host1(config-policy-list-classifier-group)#color red
host1(config-policy-list-classifier-group)#mark tcfield 7
```

4. Exit Policy List Configuration mode to save the configuration.

```
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
host1(config)#
```

5. Display the policy list.

```
host1#show policy-list routeForIPv6

                                    Policy Table
                                    ------ -----
IPv6 Policy routeForIPv6
   Administrative state: enable
   Reference count:      0
   Classifier control list: ipv6tc67, precedence 75
      color red
      mark tc-precedence 7
```

Related Topics

- ipv6 policy-list command

Creating Policy Lists for L2TP

The following example creates an L2TP policy list.

1. Create the policy list routeForl2tp.

```
host1(config)#l2tp policy-list routeForl2tp
host1(config-policy-list)#
```

2. Create the classification group to match all packets.

```
host1(config-policy-list)#classifier-group *
host1(config-policy-list-classifier-group)#
```

3. Add a rule to color packets as red, and a second rule that uses the rate-limit profile l2tpRLP10.

```
host1(config-policy-list-classifier-group)#color red
host1(config-policy-list-classifier-group)#rate-limit-profile l2tpRLP10
```

4. Exit Policy List Configuration mode to save the configuration.

```
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
host1(config)#
```

5. Display the policy list.

```
host1#show policy-list routeForl2tp

                                    Policy Table
                                    ------ -----
L2TP Policy routeForl2tp
   Administrative state: enable
   Reference count:      0
   Classifier control list: *, precedence 100
      color red
      rate-limit-profile l2tpRLP20
```

Related Topics

- l2tp policy-list command

Creating Policy Lists for MPLS

The following example creates an MPLS policy list.

1. Create the policy list routeForMpls.

   host1(config)#**mpls policy-list routeForMpls**
   host1(config-policy-list)#

2. Create the classification group.

   host1(config-policy-list)#**classifier-group * precedence 200**
   host1(config-policy-list-classifier-group)#

3. Add one rule that sets the EXP bits for all packets to 2, and a second rule that uses the rate-limit profile mplsRLP5.

   host1(config-policy-list-classifier-group)#**mark-exp 2**
   host1(config-policy-list-classifier-group)#**rate-limit-profile mplsRLP5**

4. Exit Policy List Configuration mode to save the configuration.

   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**exit**
   host1(config)#

5. Display the policy list.

```
host1#show policy-list routeForMpls

                                  Policy Table
                                  ------ -----
MPLS Policy routeForMpls
   Administrative state: enable
   Reference count:      0
   Classifier control list: *, precedence 200
      mark-exp 2 mask 7
      rate-limit-profile mplsRLP5
```

Related Topics

- mpls policy-list command

Creating Policy Lists for VLANs

The following example creates a VLAN policy list named routeForVlan. The classifier group lowLatencyLowDrop uses the default precedence of 100.

1. Create the policy list routeForVlan.

   host1(config)#**vlan policy-list routeForVlan**
   host1(config-policy-list)#

2. Create the classification group.

   host1(config-policy-list)#**classifier-group lowLatencyLowDrop**
   host1(config-policy-list-classifier-group)#

3. Create a rule that adds the lowLatencyLowDrop traffic class for all packets that fall into the lowLatencyLowDrop classification.

   host1(config-policy-list-classifier-group)#**traffic-class lowLatencyLowDrop**

4. Add a rule that sets the drop precedence for all packets that fall into the lowLatencyLowDrop classification to green.

   host1(config-policy-list-classifier-group)#**color green**

5. Add a rule that sets the user-priority bits for all packets that fall into the lowLatencyLowDrop classification to 7.

   host1(config-policy-list-classifier-group)#**mark-user-priority 7**

6. Exit to Policy List Configuration mode, then add traffic class rules for packets that conform to different CLACLs.

   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**classifier-group lowLatency**
   host1(config-policy-list-classifier-group)#**traffic-class lowLatency**
   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**classifier-group excellentEffort**
   host1(config-policy-list-classifier-group)#**traffic-class excellentEffort**
   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**classifier-group bestEffort**
   host1(config-policy-list-classifier-group)#**traffic-class bestEffort**

7. Exit Policy List Configuration mode to save the configuration.

   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**exit**
   host1(config)#

8. Display the policy list.

```
host1#show policy-list routeForVlan

                                  Policy Table
                                  ------ -----
VLAN Policy routeForVlan
   Administrative state: enable
   Reference count:      0
   Classifier control list: lowLatencyLowDrop, precedence 100
      traffic-class lowLatencyLowDrop
      color green
      mark-user-priority 7
   Classifier control list: lowLatency, precedence 100
      traffic-class lowLatency
   Classifier control list: excellentEffort, precedence 100
      traffic-class excellentEffort
   Classifier control list: bestEffort, precedence 100
      traffic-class bestEffort
```

Related Topics

- **vlan policy-list** command

Chapter 4

Creating Classifier Groups and Policy Rules

This chapter provides information for configuring policy-based routing management on E-series routers. The chapter discusses the following topics:

Classifier Groups and Policy Rules Overview

Classifier groups contain the policy rules that make up a policy list. A policy rule is an association between a policy action and an optional CLACL. The CLACL defines the packet flow on which the policy action is taken.

A policy list might contain multiple classifier groups—you can specify the precedence in which classifier groups are evaluated. Classifier groups are evaluated starting with the lowest precedence value. Classifier groups with equal precedence are evaluated in the order of creation.

NOTE: For IP policies, the **forward** command supports the **order** keyword, which enables you to order multiple forward rules within a single classifier group. (See *Using Policy Rules to Provide Routing Solutions* on page 35.)

From Policy Configuration mode, you can assign a precedence value to a CLACL by using the **precedence** keyword when you create a classifier group. The default precedence value is 100. For example:

```
host1(config-policy-list)#classifier-group ipCLACL25 precedence 21
host1(config-policy-list-classifier-group)#
```

The **classifier-group** command puts you in Classifier Group Configuration mode. In this mode you configure the policy rules that make up the policy list. For example:

```
host1(config-policy-list-classifier-group)#forward next-hop 172.18.20.54
```

To stop and start a policy rule without losing statistics, you can suspend the rule. Suspending a rule maintains the policy rule with its current statistics, but the rule no longer affects packets in the forwarding path.

From Classifier Group Configuration mode, you can suspend a rule by using the **suspend** version of that policy rule command. The **no suspend** version reactivates a suspended rule. For example:

```
host1(config-policy-list-classifier-group)#suspend forward next-hop 172.18.20.54
host1(config-policy-list-classifier-group)#no suspend forward next-hop 172.18.20.54
```

You can add, remove, or suspend policy rules while the policy is attached to one or more interfaces. The modified policy takes effect once you exit Policy Configuration mode.

Policy Rule Precedence

Because of the flexibility in creating policy lists and classifier groups, you can configure a classifier group that has multiple policy rules.

If a classifier group has multiple rules, the router uses the rules according to their precedence—not in the order in which you created the rules. The first rule listed (the forward rule) for a policy list type has the highest precedence and the last rule has the lowest. The precedence is based on the order in which the router performs rules. Rules are performed in order from lower to higher precedence. In the event of a conflict, a higher precedence rule overrides the lower precedent rule.

The precedence of rules is important if you want a specific rule to be applied. For example, if an IP policy list has both a rate-limit-profile rule (which specifies a color) and a color rule in the same classifier-group, the color specified by the color rule is always used rather than the color implied in the rate-limit-profile rule (the color rule has a higher precedence).

Table 5 lists the policy rule commands that you can use for each type of policy list. The table lists the rules in their order of precedence.

NOTE: The ES2 10G Uplink LM and the ES2 10G LM support only IP, MPLS, and VLAN interfaces.

Table 5: Policy Rule Commands and Precedence

ATM	Frame Relay	GRE	IP	IPv6	L2TP	MPLS	VLAN
forward	forward	forward	forward	forward	forward	forward	forward
color	color	color	forward interface (input, secondary input, and output policies only)	color	color	color	color
–	–	–	exception for input and secondary input policies only (not supported on ES2 10G Uplink LM or ES2 10G LM)	–	–	–	–
mark-clp (See **mark-clp command** for platform support information.)	mark-de	mark	forward next-hop for input policies only	rate-limit-profile	rate-limit-profile	rate-limit-profile	mark-user-priority
filter	filter	filter	color	user-packet-class	filter	mark-exp	filter
user-packet-class	user-packet-class	user-packet-class	rate-limit-profile	traffic-class	user-packet-class	filter	user-packet-class
traffic-class	traffic-class	traffic-class	user-packet-class	mark	traffic-class	user-packet-class	traffic-class
–	–	–	traffic-class	filter	–	traffic-class	–
–	–	–	mark	–	–	–	–
–	–	–	filter	–	–	–	–
–	–	–	log (not supported on ES2 10G Uplink LM or ES2 10G LM)	–	–	–	–

NOTE: The commands listed in this section replace the Policy List Configuration mode versions of the commands. For example, the **color** command replaces the Policy List Configuration mode version of the **color** command. The original command may be removed completely in a future release.

Related Topics

- Classifier Groups and Policy Rules Overview on page 32
- *Chapter 9, Monitoring Policy Management*
- **color** command
- **color-mark-profile** command
- **filter** command
- **green-mark** command
- **log** command
- **mark** command
- **mark-clp** command
- **mark-de** command
- **mark-exp** command
- **mark-user-priority** command
- **next-hop** command
- **next-interface** command
- **rate-limit-profile** command
- **red-mark** command
- **reference-rate** command
- **traffic-class** command
- **user-packet-class** command
- **yellow-mark** command

Using Policy Rules to Provide Routing Solutions

The next-interface, next-hop, filter, and forward rules provide routing solutions for traffic matching a classifier. A classifier can have only one action that provides a routing solution.

If you configure two routing solution rules, such as filter and forward, in the same classifier group, the router displays a warning message, and the rule configured last replaces the previous rule.

For IP policy lists, policy rules are available to enable you to make a forwarding decision that includes the next interface and next hop:

- Forward next interface—Causes an interface to forward all packets that satisfy the classification associated with that rule to the next interface specified
- Forward next hop—Causes an interface to forward all packets that satisfy the classification associated with that rule to the next-hop address specified

For example, you can route packets arriving at IP interface ATM 0/0.0 so that they area handled as indicated:

- Packets from source 1.1.1.1 are forwarded out of interface ATM 0/0.1.
- Packets from source 2.2.2.2 are forwarded out of interface ATM 2/1.1.
- All other packets are dropped.

To configure this routing policy, issue the following commands:

```
host1(config)#ip classifier-list clacIA ip host 1.1.1.1 any
host1(config)#ip classifier-list clacIB ip host 2.2.2.2 any
host1(config)#ip policy-list IpPolicy100
host1(config-policy-list)#classifier-group clacIA
host1(config-policy-list-classifier-group)#forward interface atm 0/0.1
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group clacIB
host1(config-policy-list-classifier-group)#forward interface atm 2/1.1
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group *
host1(config-policy-list-classifier-group)#filter
host1(config-policy-list-classifier-group)#exit

host1(config)#interface atm 0/0.0
host1(config-subif)#ip policy input IpPolicy100 statistics enabled
```

Configuring Policies to Provide Network Security

You can configure policy management to provide a level of network security by using policy rules that selectively forward or filter packet flows:

- Forward—Causes the packet flows that satisfy the classification associated with the rule to be routed by the virtual router
- Filter—Causes the interface to drop all packets of the packet flow that satisfy the classification associated with the rule

To stop a denial-of-service attack, you can use a policy with a filter rule. You need to construct the classifier list associated with the filter rule so that it isolates the attacker's traffic into a flow. To determine the criteria for this classifier list, you need to analyze the traffic received on an interface. *Chapter 9, Monitoring Policy Management*, describes how to capture packets into a log.

For example, you can route packets entering an IP interface (ATM 0/0.0) so that they are handled as indicated:

- Packets from source 1.1.1.1 are routed.
- TCP packets from source 2.2.2.2 with the IP fragmentation offset set to one are dropped.
- All other TCP packets are routed.
- All other packets are dropped.

To configure this policy, issue the following commands:

```
host1(config)#ip classifier-list clacIA ip host 1.1.1.1 any
host1(config)#ip classifier-list clacIB tcp host 2.2.2.2 any ip-frag-offset eq 1
host1(config)#ip classifier-list clacIC tcp any any
host1(config)#ip policy-list IpPolicy100
host1(config-policy-list)#classifier-group clacIA
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group clacIB
host1(config-policy-list-classifier-group)#filter
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group clacIC
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group *
host1(config-policy-list-classifier-group)#filter
host1(config-policy-list-classifier-group)#exit

host1(config)#interface atm 0/0.0
host1(config-subif)#ip policy input IpPolicy100 statistics enabled
```

Creating an Exception Rule within a Policy Classifier Group

To create the exception rule within an IP policy classifier group to specify the client application for the destination of packets rather than forwarding them by the forwarding controller (FC), use the **exception http-redirect** command.Doing this allows the application to then perform an application-dependent action on the content of the packet. The exception rule applies to input and secondary-input policies.

NOTE: The exception http-redirect command is not supported for the ES2 10G LM or the ES2 10G Uplink LM.

An exception rule in the input policy only takes effect if neither the input policy nor the secondary policy drops the packet. Packets dropped by input or secondary policies are not exceptioned to the SRP module. HTTP redirect is the only application that is available as a destination of the **exception** rule.

Because classifier groups can contain multiple actions, the following list describes how each rule interacts with the exception rule:

- **color**—Packets are colored and the exception rule is applied.
- **filter**—Packets are filtered and the exception rule is *not* applied. When the filter rule is present, other rules are not applied.
- **forward**—Forward rule is ignored and the exception rule is applied to packets.
- **log**—Packets are logged and the exception rule is applied.
- **mark**—Packets are marked and the exception rule is applied.
- **next-hop**—Next-hop rule is ignored and the exception rule is applied to packets.
- **next-interface**—Next-interface rule is ignored and the exception rule is applied to packets.
- **rate-limit-profile**—Rate limit is applied and the exception rule is applied to packets.
- **traffic-class**—Traffic class is set and the exception rule is applied to packets.
- **user-packet-class**—User packet class is set and the exception rule is applied to packets.
- **exception**—Exception rule is applied to packets.

Related Topics

- **exception http-redirect** command

Defining Policy Rules for Forwarding

The forward next-hop command defines a rule that creates the forwarding solution for packets matching the current CLACL.The **forward** command can be used while the policy list is referenced by interfaces. The **suspend** version suspends the forward rule within the classifier group.

For IP policy lists only:

- You can use the **forward interface** command to specify multiple interfaces and the **forward next-hop** command to specify next-hop addresses as possible forwarding solutions. If you define multiple forwarding solutions for a single CLACL, use the **order** keyword to specify the order in which the router chooses the solutions. The router uses the first reachable solution in the list, starting with the solution with the lowest order value. The default order value is 100.

NOTE: The forward interface and **forward next-hop** commands replace the **nest-interface** and **next-hop** commands.

The switch route processor (SRP) module Fast Ethernet port cannot be the destination of the **forward next-hop** and **forward next-interface** commands.

- If you specify a next-hop address as the forwarding solution, you can specify that the default route is not used as a routing solution for the next-hop address when selecting a reachable forward rule entry.
- IP interfaces referenced with this command can be tracked if they move. Policies attached to an interface also move if the interface moves. However, statistics are not maintained across the move.
- You can no longer use an interface specifier of **tunnel:mpls** with the **forward interface** command, because that usage requires IP interfaces on top of RSVP-TE tunnels. Such interfaces are no longer present in the redesigned MPLS architecture. However, you can configure a static route for an address that is not otherwise used to point to a tunnel, and then use the **forward next-hop** command in the policy:

  host1(config)#**ip route 10.10.10.10/32 tunnel mpls:foo**
  host1(config)#**ip policy-list bar**
  host1(config-policy-list-classifier-group)#**forward next-hop 10.10.10.10**

Related Topics

- forward command
- forward interface command
- forward next-hop command

Assigning Values to the ATM CLP Bit

The **mark-clp** command assigns a value of 0 or 1 to the ATM CLP bit for packets conforming to the current classifier control list.

Modules on E-series routers support classifying and marking of the ATM CLP bit according to the following rules:

- Modules on E120 and E320 routers support classifying of the ATM CLP bit only for frame-based interfaces (ATM Adaptation Layer 5 [AAL5] encapsulation), but not for individual ATM cells (ATM Adaptation Layer 0 [AAL0] encapsulation). In this case, if the CLP bit in any cell in the frame has a value of 1, the router treats the reassembled AAL5 frame as if it also had a CLP value of 1.
- Modules on E120 and E320 routers support marking of the ATM CLP bit on frame-based interfaces. In this case, every cell of the segmented frame leaves the router with the same CLP value.
- Modules on ERX-7xx models, ERX-14xx models, and the ERX-310 router support classifying and marking of the ATM CLP bit for individual ATM cells (AAL0 encapsulation), but not for frame-based interfaces (AAL5 encapsulation).

Related Topics

- **mark-clp** command

Enabling ATM Cell Mode

When you configure a rate limit profile to account for ATM cell tax, the forwarding code calculates this information to determine the size of a frame instead of using only the frame size.

- Issue the **atm-cell-mode** command to account for the ATM cell tax in statistics and rate calculations:

  host1(config-policy-list)#**atm-cell-mode**

Use the **show rate-limit-profile** command to display the state of the mode.

Related Topics

- *Chapter 9, Monitoring Policy Management*
- **atm-cell-mode** command
- **show rate-limit-profile** command

Enabling IP Options Filtering

You can filter packets with IP options on an interface:

- Issue the **ip filter-options** all command.

  host1(config-if)#**ip filter-options all**

When a packet arrives on an interface, the router checks to see if the packet contains IP options. If it does and if IP options filtering is enabled, that packet is dropped. IP options filtering is disabled by default.

Related Topics

- Classifier Groups and Policy Rules Overview on page 32
- **ip filter-options all**

Packet Tagging Overview

You can use the traffic-class rule in policies to tag a packet flow so that the QoS application can provide traffic-class queuing. Policies can perform both in-band and out-of-band packet tagging:

- Policies perform in-band tagging by using their respective mark rule to modify a packet header field. For example, IP policies use the **mark** rule to modify an IP packet heard ToS field, and Frame Relay policies use the **mark-de** rule to modify the DE bit.

- Policies perform out-of-band tagging by using the traffic class or color rule. Explicit packet coloring lets you configure prioritized packet flows without having to configure a rate-limit profile. The router uses the color to queue packets for egress queue threshold dropping as described in *Chapter 5, Creating Rate-Limit Profiles*.

For example, an Internet service provider (ISP) provides a Broadband Remote Access Server (B-RAS) service that has both video and data components, and the ISP wants to guarantee that the video traffic gets priority treatment relative to the data traffic. The ISP's users have a 1.5 Mbps virtual circuit (VC) terminating on a digital subscriber line access multiplexer (DSLAM). The ISP wants to allocate 800 Kbps of this link for video, if there is a video stream.

The ISP creates a classifier list to define a video packet flow, creates a policy to color the packets, and applies the policy to the interface:

host1(config)#**ip classifier-list video ip any any dsfield 16**
host1(config)#**ip classifier-list data ip any any dsfield 32**
host1(config)#**ip policy-list colorVideoGreen**
host1(config-policy-list)#**classifier-group video**
host1(config-policy-list-classifier-group)#**color green**
host1(config-policy-list-classifier-group)#**exit**
host1(config-policy-list)#**classifier-group data**
host1(config-policy-list-classifier-group)#**color yellow**

```
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit

host1(config)#interface atm 12/1.1
host1(config-if)#ip policy input colorVideoGreen statistics enabled
```

Creating Multiple Forwarding Solutions with IP Policy Lists

By default, the router uses a single route table lookup to determine the forwarding solution for packets. For IP policy lists only, the **forward** command enables you to configure one or more unique forwarding solutions (interfaces or next-hop addresses) that override the route table lookup. By creating a group of forwarding solutions, you can ensure that there is a reachable solution for the packets.

You can use the **order** keyword to specify the order of the group of forwarding solutions within a single forward rule. If no order value is specified, then the default order of 100 is assigned to a solution. The router evaluates the forwarding solutions in the group, starting at the solution with the lowest order value, and then uses the first reachable solution. To be considered a reachable solution, a solution must be a reachable interface or a next-hop address that has a route in the routing table. If no solutions are reachable, the traffic is dropped.

The following guidelines apply when you create a group of forwarding solutions in an IP policy list:

- You can specify a maximum of 20 forwarding solutions for a classifier.
- The interface and next-hop elements of a forwarding solution must exist within a single virtual router:
  - Next-interface elements are associated with the virtual router where that interface exists.
  - You can include an optional parameter to specify the virtual router when you define next-hop elements.
  - If only next-hop elements exist and you do not use the virtual router option, then the policy assumes the virtual router context of the command-line interface (CLI), making the policy specific to that VR. The policy can be attached only to interfaces that belong to that VR. However, the policy can still be displayed and modified from any VR. The output of the **show configuration** command displays the policy in the section of output related to that VR rather than in the section for the default VR. This behavior ensures that when you use that output for a configuration script, the policy is specific to the correct VR, and the original configuration is re-created.
- If you specify both an interface element and a next-hop address element, then they both must be reachable to be used. Also, the interface must be the correct interface for the next-hop address.
- If you specify a next-hop address, then you can optionally specify that the default route be ignored.

- If you delete the target (interface or next-hop address) referenced in a rule, that solution is replaced by the null interface but retains the same order number in the policy list. The null interface is always considered unreachable.
- When a forwarding solution with a lower order value than the currently active solution becomes reachable, the router switches to the lower-ordered solution.
- If two rules that have the same order value are reachable, then the rule that was created first is used.

NOTE: The **forward interface** and **forward next-hop** commands are replacing the **next-interface** and **next-hop** commands, which do not support multiple forwarding solutions in a single forward rule.

In the following sample classifier group of a policy list, the forwarding solution of ATM interface 0/0.1 has the lowest order value in the group, and would therefore be selected as the solution for the policy list. However, if this interface is not reachable, the router then attempts to use the solution with the next higher order; which would be ATM interface 12/0.1. If none of the solutions in the group is reachable, the traffic is dropped.

```
host1(config-policy-list)#classifier-group westfordClacl precedence 200
host1(config-policy-list-classifier-group)#forward interface atm 0/0.1 order 10
host1(config-policy-list-classifier-group)#forward interface atm 12/0.1 order 50
host1(config-policy-list-classifier-group)#forward interface atm 3/0.25 order 300
```

NOTE: You can use the **suspend** version of the command to suspend an individual entry in a group of forwarding solutions. The forward rule remains active as long as there is a reachable or active entry in the group of forwarding solutions. If you suspend all entries in the group, the status of the forward rule is changed to suspended.

Creating a Classifier Group for a Policy List

To create a classifier group for a policy list and assigns precedence to the specific CLACL that is referenced in the group:

1. Create a classifier group.

   ```
   host1(config-policy-list)#classifier-group C1 parent-group IPG1
   ```

2. Assign a precedence to the CLACL.

   ```
   host1(config-policy-list)#classifier-group westfordClacl precedence 150
   ```

3. Create a hierarchical policy parameter list.

   ```
   host1(config)#policy-parameter A hierarchical
   host1(config)#parent-group EPG1
   host1(config-parent-group)#exit
   host1(config)#ip policy-list POL
   ```

```
host1(config-policy-list)#classifier-group C1 external parent-group EPG1
parameter A
host1(config-policy-list)#exit
```

The **no** version removes the classifier group and its rules from a policy list. The **precedence** keyword specifies the order in which a classifier group is evaluated compared to other classifier groups. Classifier groups are evaluated from lowest to highest precedence value (for example, a classifier group with a precedence of 1 is used before a classifier group with a precedence of 2). Classifier groups with equal precedence are evaluated in the order of creation, with the group created first having precedence. A default value of 100 is used if no precedence is specified.

The **parent-group** keyword creates a parent group in a rate-limit hierarchy for IP, IPv6, L2TP, and MPLS. The **external parent-group** keyword creates an external parent group in a rate-limit hierarchy for IP, IPv6, L2TP, and MPLS. All packets matching the classifier are sent to the parent group for further processing, except for packets dropped by the classifier using the filter rule.

More than one classifier group can have the same parent group, which enables you to create hierarchies.

NOTE: Empty classifier groups have no effect on the router's classification of packets and are ignored by the router. You might inadvertently create empty classifier groups in a policy if you use both the newer CLI style and the older CLI style, which used the Policy List Configuration mode version of the classifier list commands.

Related Topics

- Classifier Groups and Policy Rules Overview on page 32
- *Chapter 5, Creating Rate-Limit Profiles* for examples of using this command to rate limit traffic flows
- *Chapter 9, Monitoring Policy Management*
- **aggregation-node** command
- **classifier-group** command
- **ip policy-parameter hierarchical** command
- **ip policy-parameter reference-rate** command
- **ipv6 policy-parameter hierarchical** command
- **ipv6 policy-parameter reference-rate** command
- **l2tp policy-parameter hierarchical** command
- **l2tp policy-parameter reference-rate** command
- **mpls policy-parameter hierarchical** command

- **mpls policy-parameter reference-rate** command
- **next-parent** command
- **parent-group** command
- **policy-parameter hierarchical** command

Chapter 5

Creating Rate-Limit Profiles

This chapter provides information for configuring rate-limit policy management on E-series routers.

This chapter discusses the following topics:

- Bandwidth Management Overview on page 82
- Rate-Limiting SRP Traffic Flows on page 85

For information on monitoring rate-limit profiles, see *Chapter 9, Monitoring Policy Management*.

Rate Limits for Interfaces Overview

To configure rate limiting for interfaces, you first create a rate-limit profile, which is a set of bandwidth attributes and associated actions. Your router supports two types of rate-limit profiles—one-rate and two-rate—for IP, IPv6, LT2P, and MPLS Layer 2 transport traffic. You next create a policy list with a rule that has rate limit as the action and associate a rate-limit profile with this rule.

You configure rate limit profiles from Global Configuration Mode.

NOTE: Commands that you issue in Rate Limit Profile Configuration mode do not take effect until you exit from that mode.

When packets enter an interface that has a rate-limit profile applied, the router performs the following:

- Counts the number of bytes (packets) over time
- Categorizes each packet as committed, conformed, or exceeded
- Assigns a transmit, drop, or mark action

NOTE: Mark actions and mask values are supported only on IP, IPv6, and MPLS rate-limit profiles. They are not supported on hierarchical rate limits, but are replaced by color-mark profiles.

An additional function of rate limiting is to apply a color code to packets assigned to each category: green for committed, yellow for conformed, and red for exceeded. The system uses the color code internally to indicate drop preference when an outbound interface is congested.

Rate limiters are implemented using a dual token bucket scheme: a token bucket for conformed (yellow) packets and a token bucket for committed (green) packets. One token is synonymous with one byte. The capacity of the buckets is the maximum number of tokens that can be placed in each bucket.

You configure the bucket capacity with the peak burst parameter or the committed burst parameter. The burst parameters are in bytes (not bytes per second), which is the number of tokens in a full bucket. When a packet passes through a rate limiter, its size is compared to the contents of both buckets, the packet is categorized, and the rate-limiter action is taken on the packet.

Peak rate and committed rate determine the fill rate of their respective buckets. If you set the committed rate to 128,000 bps, tokens are added to the committed (green) bucket at a rate of 128,000 bps (16 K bytes per second), regardless of the traffic. If no traffic passes through the rate limiter, the bucket continues to fill until it reaches the committed burst setting.

Traffic passes through the rate limiter causing a draining of tokens. The drain rate is dependent on how large the packets are and how much time elapses between packets. At any given instant the level of tokens in each bucket is a function of the fill rate, size of packets, and elapsed time between packets.

When packets are received on an interface with a rate limiter applied, the level of tokens in each bucket dynamically changes in both of the following ways:

- Tokens are added every 100-ms sample period
- Tokens are removed based on the size and rate of incoming packets

Hierarchical Rate Limits Overview

In another type of rate limiting, rate-limit hierarchies enable lower priority traffic to access unused bandwidth allocated for real-time traffic, such as voice or video, during times when no real-time traffic is flowing. IP subscribers receive multiple services, such as Web, video, and file transfer, that have a maximum bandwidth. A rate-limit hierarchy can apply a common rate limit to several classified flows, enabling them to share bandwidth according to the preferences set in the hierarchical rate limits.

You can also use rate-limit hierarchies in a layer 2 (ATM) access network for DSL where many routing gateways lead into one Broadband Access Server. The Broadband Access Server uses rate-limit hierarchies to allocate shareable bandwidth to each routing gateway, which enables unused bandwidth from one routing gateway to be used by others. The hierarchy in the rate limit represents the hierarchy in the access network.

Rate-limit hierarchies enable you to share unused bandwidth dynamically, taking unused preferred bandwidth. They also enable real-time traffic to use all guaranteed bandwidth at any time without violating the configured limit on the total interface bandwidth. While preferred traffic fluctuates, the interface rate limit adjusts, dropping non-preferred packets to keep the total flow through the interface under a configured maximum rate, because preferred packets cannot be dropped by the shared rate limits, only by their individual rate limits.

Shared rate limits in the hierarchy keep the combined traffic below a configured maximum without dropping preferred packets. Preferred packets always reduce tokens on these rate limits, making their token counts negative, if necessary. Later non-preferred packets are then dropped in greater volume, bringing the total traffic through the shared rate limit below its configured maximum.

Every packet passing through a rate limit hierarchy has an *owner*, which is the last rate limit that can modify the packet; for example, by changing its color or dropping it. Preferred packets are owned by their individual preferred rate limits, which do not transfer ownership of the packet while the packet traverses the hierarchy. Ownership of non-preferred packets is transferred while they move from one rate-limit to the next in the hierarchy, so shared rate limits can change the packet color or drop them.

Hierarchical Classifier Groups

Rate-limit hierarchies can be intra-interface, where different flows from classifier groups are in one policy attachment on an interface. Each time the policy is attached to another interface the rate-limit hierarchy is replicated, with no rate limits shared between attachments. Hierarchical rate-limits are only applied at forwarding interfaces because they provide the most accurate classification of packets.

You can configure rate-limit hierarchies by defining a hierarchy of policy classifier and parent groups, each with a rate limit. This hierarchy applies to the packet flow on one interface attachment for the policy. Each policy attachment creates its own copy of the rate-limit hierarchy. There are no shared rate limits across interface attachments.

A policy-based rate-limit hierarchy consists of classifier groups with an aggregate node policy object. Aggregate nodes create the interior nodes of a policy-based hierarchy; they are not classifier groups and the only policy rule applicable to them is the rate limit rule. Every classifier group or aggregate node can select another aggregate node as its parent. The policy manager ensures that these choices always result in a hierarchy. Not every classifier group with a parent aggregate node must have a rate limit rule; multiple classifier groups can share a common parent group, which may have a rate limit rule.

A policy imposes a limit of three parent groups that can be traversed from any classifier group. However, the total number of parent groups in one policy can be up to 512, but every packet must pass through no more than three parent groups at any point.

In a hierarchy of rate limits, a rate limit can be *color-blind* or *color-aware*; color-blind rate limits run the same algorithm for all packets, regardless of their color. Color-aware rate limits can change the algorithm used, depending on the color of the incoming packet (possibly set in the previous rate limit or an earlier policy, such as a VLAN policy on ingress or an IP policy). The color mark profile action changes the ToS field for the packet, depending on packet type (EXP for MPLS, DSCP or ToS for IPv4), and transmits the packet. If the mark action uses a color-mark profile, the ToS values marked can depend on the color of the packet.

Hierarchical Rate-Limit Profiles

Hierarchical rate-limit profiles are independent from interface types. You can apply the green, yellow, or red mark values to the rate-limit profile for every type of forwarding interface that accepts ToS marking for packets. The same rate limit can be reused for a different interface type. Hierarchical rate limits have two-rate or TCP-friendly rate types.

The value applied to the ToS field is configured in the CLACL group for green, yellow, or red packets but the coloring of the packet as green, yellow, or red depends on the entire rate-limit hierarchy.

- Preferred packets are transmitted unconditionally. Rate limits that process packets transmitted unconditionally always decrement their token count, if necessary, making it negative.
- Red packets cannot be transmitted unconditionally, to avoid cases where an aggregate rate limit is oversubscribed with transmit-unconditional rates.
- Color-aware uses the incoming packet color in its algorithm
- Not promoting packets means that if the packet enters the rate limit as yellow and the rate-limit then determines that it is green, the packet remains yellow. If the rate limit determines it is red, then the packet is colored red.

A rate-limit rule is an instance of a rate-limit profile. The same profile can be used to create many rate-limit rules in the same hierarchy or in different rate-limit hierarchies. The classifier group that defines the flow can use a mark rule with color-mark profile to set the packet ToS field based on the packet color. A rate-limit hierarchy invoked from the classifier group is one way of changing the packet color; the rate-limit hierarchy is invoked before the classifier group runs the mark rule to set the packet ToS.

Hierarchical Rate-Limit Actions

Every packet traversing a rate-limit hierarchy has an owner that is defined by the last rate limit that can apply its actions to the packet; this is a configuration option.

A rate limit in the hierarchy that does not own the packet only decrements its tokens, but cannot perform any of the following actions:

- Transfer ownership of the packet to the next rate limit.
- Retain ownership of the packet but consume tokens from the remaining rate limits in the hierarchy.
- Exit the rate-limit hierarchy, making that rate limit the final one for the packet.

These actions become the same action if the hierarchy has only one rate limit. Combining these actions with the additional choices to transmit or drop packets results in the following possible actions:

- Drop—Drops the packet at that rate limit in the hierarchy. The packet does not change the state of any rate limit further down the hierarchy.
- Transmit final—Sets the packet color and ends the packet's traversal of the rate-limit hierarchy at the current rate limit. The packet is forwarded and the rate limits further down the hierarchy are not affected. Because transmit final is based on the result of the rate limit, transmit is not an attribute of the node in the rate-limit hierarchy. Committed packets can exit the hierarchy while conformed and exceeded packets continue to the next rate limit.

- Transmit conditional—Sets the packet color to the result calculated by the rate limit and forwards the packet to the next rate limit for processing, also transferring ownership of the packet to the next rate limit. The next rate limit can then set the packet color according to the state of its token buckets and apply its actions to the packet. The transmit conditional option is the same as connecting the two rate limits in series.

- Transmit unconditional—Sets the packet color to the result calculated by the rate limit, retains ownership of the packet, and forwards the packet to the next rate limit. Later rate limits only decrement their current token counts by the packet length but do not otherwise affect the packet, either by changing its color or applying their actions to it. Although the packet is not affected, the remaining rate limits change because the token counts are reduced, making them more likely to make other packets conformed or exceeded. Transmit unconditional is not allowed as an exceeded action.

  After the transmit-unconditional completes, the packet traverses to the end of the hierarchy. Because ownership of the packet has been retained, no rate limit further down can apply its actions to it. Some of the later rate limits might already have very low token counts, which must still be decremented when processing a transmit-unconditional packet (if necessary, by making the token count negative). Negative token counts enable the remaining rate limits to restrict the total traffic through them to their peak rate (over a large enough averaging interval, which is a function of rates and burst sizes only). Transmit unconditional packets traversing the rate-limit hierarchy reduce the number of tokens available for other packets.

A rate limit has one of the four preceding actions configured for each possible result: committed, conformed, and exceeded. (Transmit unconditional is not allowed as an exceeded action.) The action taken depends only on the result of that rate limit, its rates, burst sizes, and current token state. In addition, the rate limit assigns a color to the packet, depending on both the result of the rate limit and the packet's incoming color. The final color after a packet has finished traversing a rate-limit hierarchy is a function of all the rate limits that owned the packet.

Policy actions are processed in the following order:

1. log
2. filter
3. traffic class
4. user packet class
5. next hop
6. rate limit
7. color status
8. color action

9. parent group

10. mark

The mark action is the last action that occurs, after parent-group, so that the color-mark profile can mark the packet with the final color from the hierarchy.

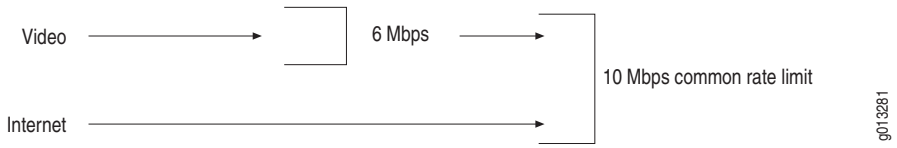
NOTE: To avoid saturation when using dual token buckets, the total amount of yellow transmit unconditional traffic should be less than the peak rate minus the committed rate; the green transmit unconditional traffic should be less than the committed rate.

Multiple Flows Sharing Preferred Bandwidth Rate-Limiting Hierarchical Policy Example

Figure 2 shows an interface with an attached policy that has a Video classifier that singles out a substream of the packets flowing on that interface. The Video classifier can be allocated 6 Mbps out of the 10 Mbps interface rate. All other packets on the interface are Internet. The common rate limit cannot drop Video packets, but must limit the total flow (Video and Internet) to under 10 Mbps. Internet traffic can use the Video bandwidth when there are no active Video calls, while avoiding hard partitioning of interface bandwidth.

NOTE: To avoid rate-limit saturation, we recommend that you set the rate limit profile to color-aware when the rate limit is set to receive transmit conditional,.

Figure 2: Multiple Flows Sharing Preferred Bandwidth



host1(config)#**rate-limit-profile video two-rate hierarchical**
host1(config-rate-limit-profile)#**committed-action transmit unconditional**
host1(config-rate-limit-profile)#**conformed-action transmit unconditional**
host1(config-rate-limit-profile)#**exceeded-action drop**
host1(config-rate-limit-profile)#**peak-rate 60000000**
host1(config-rate-limit-profile)#**exit**

host1(config)#**rate-limit-profile common two-rate hierarchical**
host1(config-rate-limit-profile)#**color-aware**
host1(config-rate-limit-profile)#**committed-action transmit conditional**
host1(config-rate-limit-profile)#**conformed-action transmit conditional**
host1(config-rate-limit-profile)#**exceeded-action drop**
host1(config-rate-limit-profile)#**peak-rate 100000000**
host1(config-rate-limit-profile)#**exit**

host1(config)**#policy-list mycompany**
host1(config-policy-list)#**classifier-group video parent-group all**
host1(config-policy-list-classifier-group)#**rate-limit-profile video**
host1(config-policy-list-classifier-group)#**exit**

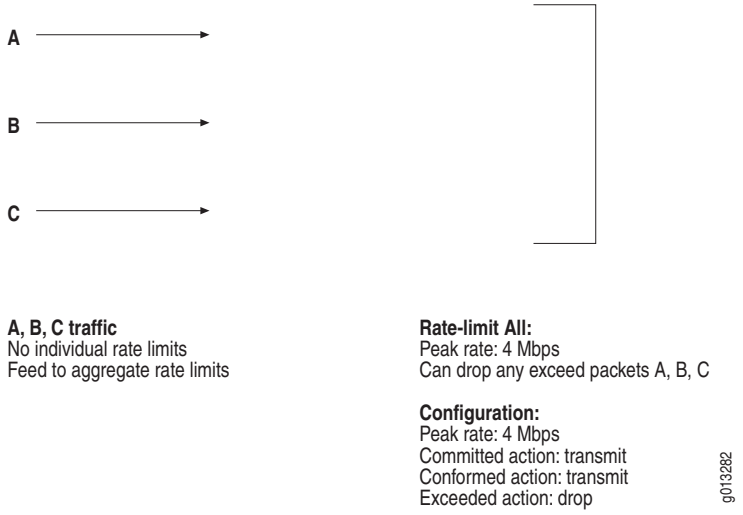
```
host1(config-policy-list)#classifier-group * parent-group all
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit

host1(config-policy-list)#parent-group all
host1(config-policy-list-parent-group)#rate-limit-profile common
host1(config-policy-list-parent-group)#exit
```

In this example, the rate limit Common is color-aware, using the color of the incoming packets instead of setting them to Green. This causes the rate limit Preferred to send 6 Mbps of yellow, transmit unconditional packets. The rate limit Common counts the packets against the yellow token bucket, which has a rate of 10 Mbps. However, if the rate limit Common is color-blind, it treats all packets as Green so the green token bucket gets 6 Mbps of transmit unconditional traffic, which eventually causes all packets to be saturated and dropped.

Multiple Flows Sharing a Rate Limit Rate-Limiting Hierarchical Policy Example

Figure 3 shows an interface that has one rate limit and three classified flows, A, B, and C. The combined traffic for A, B, and C must be below a peak rate of 4 Mbps, but each individual flow can burst up to that amount. Statistics can be collected separately on A, B, and C, while limiting only the aggregate of all three. None of the flows has any preference in accessing the rate limit and the rate limit is shared on a first-come first-serve basis.

Figure 3: Multiple Packet Flows Sharing a Rate Limit



This example uses committed and conformed actions for a preferred rate limit profile so that the common rate limit drops only exceeded packets (those packets that raise the traffic load above 4 Mbps); packets below 4 Mbps are transmitted. By specifying **classifier-group * parent-group all**, all packets are sent to the parent group. There is no individual rate limit so that those packet use any available, unused bandwidth in the parent group rate limit.

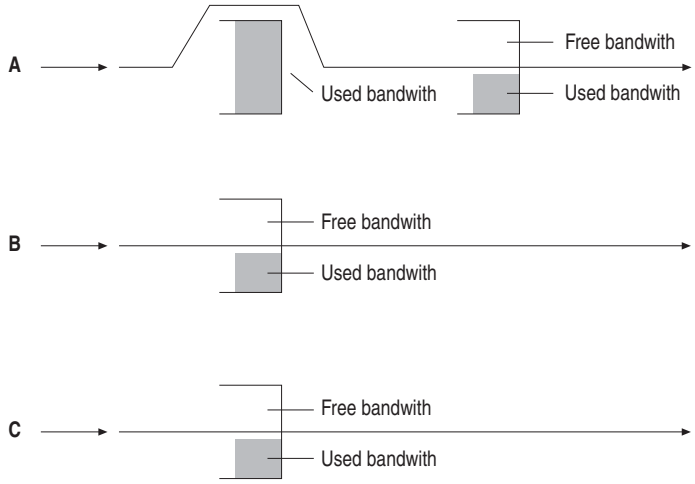
```
host1(config)#rate-limit-profile All two-rate hierarchical
host1(config-rate-limit-profile)#committed-action transmit conditional
host1(config-rate-limit-profile)#conformed-action transmit conditional
host1(config-rate-limit-profile)#exceeded-action drop
host1(config-rate-limit-profile)#peak-rate 40000000
host1(config-rate-limit-profile)#exit

host1(config)#policy-list rlpshare
host1(config-policy-list)#classifier-group A parent-group All
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit

host1(config-policy-list)#classifier-group B parent-group All
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit

host1(config-policy-list)#classifier-group C parent-group All
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit

host1(config-policy-list)#parent-group All
host1(config-policy-list-parent-group)#rate-limit-profile All
host1(config-policy-list-parent-group)#exit
```

Shared Pool of Additional Bandwidth with Select Flows Rate-Limiting Hierarchical Policy Example

Figure 4 shows three classified flows, A, B, and C, each of which has an individual rate limit with a peak rate of 1 Mbps. If flow A is exceeding its peak rate, rather than drop the packet, the flow tries to use any bandwidth left in a shared rate limit (extrabw) of peak rate of 2 Mbps. The packet is dropped only if both the individual and the shared rate limit have no bandwidth left.

The total flow is limited to 5 Mbps, which is the sum of all the individual peak rates plus the peak rate of the shared rate limit. Individual flows A, B, and C are limited to a maximum of 3 Mbps (1 Mbps from its individual rate limit and up to 2 Mbps if it can consume the entire shared pool); however, it cannot go below a 1 Mbps rate because of the other flows. A shared rate limit enables many flows to share the extra bandwidth dynamically.

Figure 4: Shared Pool of Additional Bandwidth with Select Flows



This example uses **transmit final** so that those packets do not pass through the common rate limit. Transmit final also indicates that there is no shared maximum. If the packets are committed or conformed, they do not need to borrow extra bandwidth or subtract tokens from it. The example uses **exceeded action transmit conditional** so that packets above the individual rate-limit maximum are not dropped but sent to the next rate limit in the hierarchy. Because this is **transmit conditional**, ownership of the packet also transfers so the common rate limit can drop these packets if it has no bandwidth left.

host1(config)#**ip rate limit-profile indiv two-rate**
hierarchicalhost1(config-rate-limit-profile)#**committed-action transmit final**
host1(config-rate-limit-profile)#**conformed-action transmit final**
host1(config-rate-limit-profile)#**exceeded-action transmit conditional**
host1(config-rate-limit-profile)#**peak-rate 10000000**
host1(config-rate-limit-profile)#**exit**

host1(config)#**rate-limit-profile extrabw two-rate hierarchical**
host1(config-rate-limit-profile)#**committed-action transmit conditional**
host1(config-rate-limit-profile)#**conformed-action transmit conditional**
host1(config-rate-limit-profile)#**exceeded-action drop**
host1(config-rate-limit-profile)#**peak-rate 20000000**
host1(config-rate-limit-profile)#**exit**

```
host1(config)#policy-list mypolicy
host1(config-policy-list)#classifier-group A parent-group extrabw
host1(config-policy-list-classifier-group)#rate-limit-profile indiv
host1(config-policy-list-classifier-group)#exit

host1(config-policy-list)#classifier-group B parent-group extrabw
host1(config-policy-list-classifier-group)#rate-limit-profile indiv
host1(config-policy-list-classifier-group)#exit

host1(config-policy-list)#classifier-group C parent-group extrabw
host1(config-policy-list-classifier-group)#rate-limit-profile indiv
host1(config-policy-list-classifier-group)#exit

host1(config-policy-list)#parent-group extrabw
host1(config-policy-list-parent-group)#rate-limit-profile extrabw
host1(config-policy-list-parent-group)#exit
```

Aggregate Marking with Oversubscription Rate-Limiting Hierarchical Policy Example

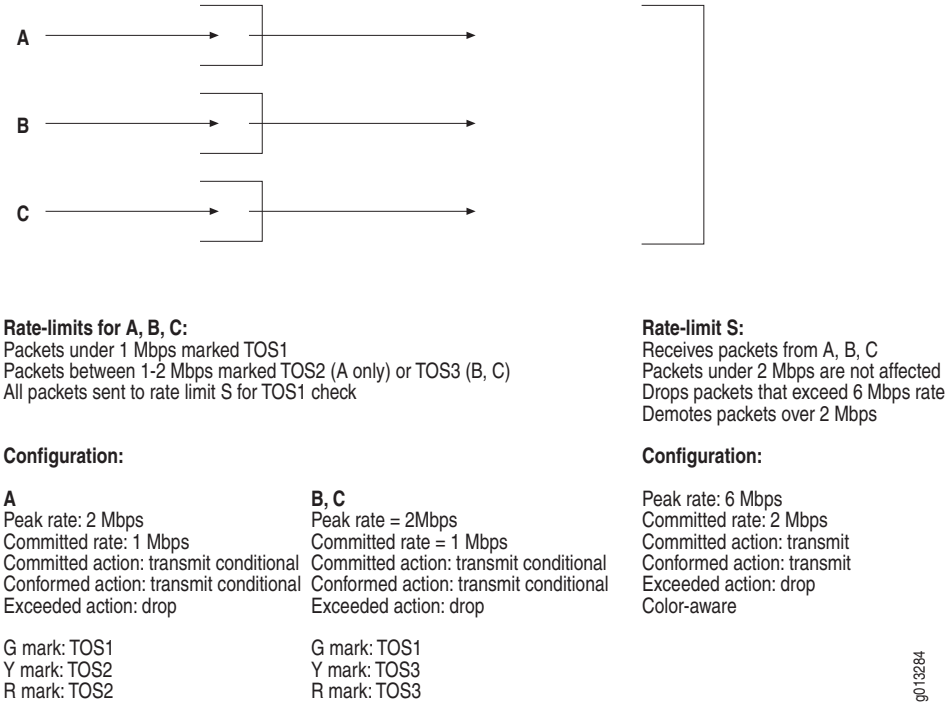
Figure 5 shows an aggregate rate limit that enables up to 2 Mbps of traffic to be sent with ToS marking TOS1. Traffic above that rate is sent with marking TOS2 or TOS3 (depending on packet type) and traffic above 6 Mbps is dropped. The 2 Mbps of TOS1 is oversubscribed among individual flows A, B, and C, each of which can have up to 1 Mbps of TOS1 traffic. An individual flow can mark a packet TOS1, but if there is insufficient bandwidth at the shared rate limit because of oversubscription, the packet is demoted and remarked.

The demoted packets from flow A are marked as TOS2 but the demoted packets from flows B and C are marked as TOS3. The shared rate limit determines whether to demote the packet, in which case each individual rate limit selects the new ToS marking. Individual flows are not required to mark demoted packets with the same value.

The committed and conformed actions are transmit conditional so that all packets also go through rate limit S, because rate limit S imposes the limit of 2 Mbps of TOS1 traffic (total across A, B, and C).

Committed packets are transmitted conditionally to rate limit S, which has a peak rate of 6 Mbps and a committed rate of 2 Mbps; these packets can be demoted by S to Y (yellow), in which case they are remarked TOS2 or TOS3. If S leaves them as G (green), they are marked as TOS1. All conformed packets from A, B, and C are also transmitted conditionally to S but arrive as Y because rate limits do not promote packets in color. S is color-aware so these Y packets do not take away G tokens, leaving them reserved only for the G packets coming from A, B, and C.

Figure 5: Aggregate Marking with Oversubscription



host1(config)#**rate-limit-profile indiv two-rate hierarchical**
host1(config-rate-limit-profile)#**committed-action transmit conditional**
host1(config-rate-limit-profile)#**conformed-action transmit conditional**
host1(config-rate-limit-profile)#**exceeded-action drop**
host1(config-rate-limit-profile)#**committed-rate 10000000**
host1(config-rate-limit-profile)#**peak-rate 20000000**
host1(config-rate-limit-profile)#**exit**

host1(config)#**rate-limit-profile S two-rate hierarchical**
host1(config-rate-limit-profile)#**committed-action transmit conditional**
host1(config-rate-limit-profile)#**conformed-action transmit conditional**
host1(config-rate-limit-profile)#**exceeded-action drop**
host1(config-rate-limit-profile)#**committed-rate 20000000**
host1(config-rate-limit-profile)#**peak-rate 60000000**
host1(config-rate-limit-profile)#**color-aware**
host1(config-rate-limit-profile)#**exit**

host1(config)#**ip color-mark-profile A**
host1(config-color-mark-profile)#**green-mark TOS1**
host1(config-color-mark-profile)#**yellow-mark TOS2**
host1(config-color-mark-profile)#**red-mark TOS2**
host1(config–color-mark-profile)#**exit**

host1(config)#**ip color-mark-profile BC**
host1(config-color-mark-profile)#**green-mark TOS1**
host1(config-color-mark-profile)#**yellow-mark TOS3**
host1(config-color-mark-profile)#**red-mark TOS3**
host1(config–color-mark-profile)#**exit**

```
host1(config)#policy-list TOS1_oversubsribed
host1(config-policy-list)#classifier-group A parent-group S
host1(config-policy-list-classifier-group)#rate-limit-profile indiv
host1(config-policy-list-classifier-group)#mark profile A
host1(config–classifier-group)#exit

host1(config-policy-list)#classifier-group B parent-group S
host1(config-policy-list-classifier-group)#rate-limit-profile indiv
host1(config-policy-list-classifier-group)#mark profile BC
host1(config–classifier-group)#exit

host1(config-policy-list)#classifier-group C parent-group S
host1(config-policy-list-classifier-group)#rate-limit-profile indiv
host1(config-policy-list-classifier-group)#mark profile BC
host1(config-policy-list-classifier-group)#exit

host1(config-policy-list)#parent-group S
host1(config-policy-list-parent-group)#rate-limit-profile S
host1(config-policy-list-parent-group)#exit
```

Color-Aware Configuration for Rate-Limiting Hierarchical Policy

Common to many rate-limit hierarchies is a large aggregate rate limit that receives packets from many smaller individual rate limits. An individual rate limit can mark a packet yellow but, if few individual flows are active, the aggregate rate limit is likely to try to promote it to green, overriding the individual rate limit. For this reason, rate limits never promote packets in color; color-aware rate limits use the incoming color in their algorithm, but the final result is always equal to or less than the initial packet color.

Rate-limit profiles for rate-limit hierarchies include a non-default configuration option for color-aware. For two-rate rate limits this option enables the color-aware algorithm. If hierarchical, TCP-friendly one-rate rate limits have a color-aware algorithm defined.

In the following color-aware example, the non-preferred packets do not take any green tokens from rate-limit A, leaving them all for preferred packets. Preferred packets may take green and also take yellow tokens (which reduces the flow of non-preferred). In this way the non-preferred packets do not reduce the number of green preferred packets, only the number of yellow preferred packets; preferred packets are then marked from a color-mark profile.

```
class non-preferred parent A
  color yellow

class preferred parent A
  mark profile cm
parent A
   rate-limit A         !! a color-aware rate limit
```

The color-mark profile translates the packet color, which is independent of its type, to a type-dependent mark for ToS or EXP and applies it to a packet after it has exited the rate-limit hierarchy. If no translation is configured for a color, then packets of that color are not changed.

Transmit-unconditional packets entering a color-aware rate limit uses the color on the packet for the rate-limit algorithm. Doing this ensures that the color-aware rate limit depletes tokens from the token buckets to account for these packets.

Every packet sent through a rate-limit hierarchy is either dropped inside the hierarchy or emerges with a green, yellow, or red color assigned to it by the rate-limit hierarchy. The color depends on the last rate limit in the hierarchy that owned the packet and all prior rate limits. The green, yellow, or red classification applies to packets of any type and is not interface-type dependent.

A packet that has traversed the hierarchy either has been dropped or emerges with a color (green, yellow or red). This final color can be used by a mark rule with a color-mark profile to select the ToS marking for the packet. Because this operation is interface-type dependent, the actual value is configured where the packet entered the hierarchy; however, the color is set by the entire rate-limit hierarchy.

We recommend that all rate-limit profiles that receive transmit unconditional packets should be color-aware. If not color-aware, yellow transmit unconditional packets are processed through both the green and yellow token buckets; if the green rate is low, this causes an oversubscription of transmit unconditional packets and leads to saturation. By making the rate limit color-aware, the yellow transmit unconditional packets ar counted only against the yellow token bucket.

Related Topics

- **color** command
- **color-aware** command
- **color-mark-profile** command
- **green-mark** command
- **red-mark** command
- **yellow-mark** command

Percent-Based Rates for Rate-Limit Profiles Overview

Percent-based rate-limit profiles enable you to divide the reference rate as percentages instead of specific values. You can specify the reference rate on each interface and specify these rates in terms of percentage of this reference rate within the rate-limit profile to derive the appropriate rate. This enables you to define rate-limit profiles with rates in terms of percentage and bursts in terms of milliseconds.

You can use percent-based rate-limit profiles to:

- Configure rates in rate-limit profiles based on a percentage of a parameter. You can assign values to these parameters at the time of attachment, which enables you to use the same policy for multiple interfaces with different parameter values.
- Specify burst sizes in milliseconds when you configure percent-based rate-limits.
- Provide a generic way to configure and use policy parameters. You can use parameter names when you create policy objects and defer assigning values to these parameters until policy attachment. This enables you to share policy objects by attaching the same policy at multiple interfaces with different parameter values. You do not have to specify values each time you attach a policy; if you do not specify interface-specific, the system uses the global value.

Policy Parameter Reference-Rate

You can use a policy parameter reference-rate to derive the rates in rate-limit profiles. You can configure rate-limit profiles as a percentage of this parameter. The system calculates the rate at the time of attachment using the value assigned to this parameter for that interface.

If you do not specify a value for this parameter in Interface Configuration mode, then the Global configuration value is used.

You can modify the value of this parameter in Global Configuration mode or Interface Configuration mode. In Interface Configuration mode, you can change the value using the **increase** keyword.

If you use the **no** version of the command in Interface Configuration mode, the parameter value is set to the global default value. The **no** version of the command with the **increase** keyword decrements the value. The parameter value cannot have a negative value. The **no** version of the command in Global Configuration mode deletes the parameter if it is not used anywhere else.

Modified values affect the rates in the rate-limit profiles that are using the reference-rate parameter.

Specifying Rates Within Rate-Limit Profiles

Within a rate-limit profile you can specify the rate either as a percentage or a specific value. In two-rate rate-limit profiles, you can select committed rate and peak rate. You can specify one rate in terms of percentage and another as a specific value. Also, one rate can be a percentage of one parameter and another rate can be a percentage of another parameter.

If the rate in a rate-limit profile is *x* percent, then the actual rate can be calculated from a parameter value as:

Actual rate (in bits per second) = (parameter value **x*)/100

The committed rate can be in the range 0—100 percent of the parameter value. The peak rate can be in the range 0—1000 percent of the parameter value.

The parameter value derives the appropriate rate within the rate-limit profile using a percentage. There are no validations to make the total rate less than or equal to the parameter value.

Specifying Burst Sizes

Within a rate-limit profile you can specify the burst size in milliseconds or bytes. Because rate-limit profiles have multiple rates and no restrictions, you can specify one burst in terms of milliseconds and another as bytes whether or not the corresponding rate is a percentage.

If the burst size is *m* milliseconds, it is calculated as:

Burst size in bytes = (rate in bps * *m*) / (8*1000)

In this example, the burst size can be in the range 0—10000 ms (10 seconds).

The maximum burst size is 4294967295 bytes (32 bit).

If you do not set the burst size, the system sets the default committed burst and peak burst to 100 ms. If the default burst size is less then 8192, the system changes it to 8192.

Using Service Manager with Merged Policies

When you use the Service Manager, you can attach multiple policies to the same interface point with the **merge** keyword and these policies are then merged into a new policy. The **increase** keyword enables you to change the parameter value for the profile.

If you activate the service without the increase keyword, the interface-specific value of the parameter is set to the value specified in the profile. However, if you activate the service with the **increase** keyword, the interface-specific value of the parameter increases by the value specified in the profile. If there was no interface-specific value at the time of activation of the profile with the **increase** keyword, then it increases from 0.

If you deactivate the service that used the **increase** keyword, the value of the parameter decreases. But if the profile did not use the **increase** keyword, deactivation does not change the current interface-specific value for that parameter. The interface-specific parameter remains until the interface is deleted.

Policy Parameter Configuration Considerations

The following list describes the rules for using policy parameters:

- Policy parameter names must be unique regardless of its type. If you configure a policy parameter with a reference-rate type, then you cannot configure it with another type until it is deleted.
- You can create policy parameters in Global Configuration mode and in Interface Configuration mode in any order.
- In Global Configuration mode, you can assign a parameter type to a parameter name and assign a default value for this parameter.

- If a parameter is configured in Global Configuration mode, but you do not assign a default value, then the system assigns a default value to the parameter. The system default value for any parameter of type reference-rate is 64K (65536).

- In Interface Configuration mode, you assign a parameter type and value for an interface. Policy parameters configured in Interface Configuration mode that have interface-type IP or L2TP specified with the command associate the command with the respective interface in the stack.

- If a parameter is configured in Interface Configuration mode without configuring it in Global Configuration mode, a global configuration is automatically created for this parameter with the type specified in interface configuration and a system-specified default value.

- A parameter value specified in Interface Configuration mode overrides the value specified in Global Configuration mode.

- If the parameter is not configured in Interface Configuration mode, the value from the global configuration is used. If the global value satisfies most of the interfaces, then you do not have to configure parameters for each interface separately, which reduces the number of configuration steps you need to take.

- When you delete an interface, the interface-specific configuration of the parameter is deleted. However, the global configuration remains until you delete it whether it was created explicitly in Global Configuration mode or automatically created in Interface Configuration mode.

  For example, you can configure policy parameter param1 of type reference-rate in Global Configuration mode with a default value of 100000 and then configure it as 200000 in Interface Configuration mode for inf1. If you configure a policy parameter as 500000 in Interface Configuration mode for interface inf1, the system automatically creates parameter param2 with a 64K (65536) global default value. When you delete interface inf1, the system deletes the interface-specific configuration for param1 and param2, but the global configuration values of 100000 and 64K (65536) remain until you explicitly delete them.

- You must create policy parameters in either Global Configuration mode or Interface Configuration mode before they can be used or referenced as policy objects. For example. before you define a rate in a rate-limit profile in terms of percentage of a policy parameter param1, you must configure param1 as parameter type reference-rate.

- You can configure multiple policy parameters; there are no restrictions on the number of parameters.

- If you modify a policy parameter value in Interface Configuration mode, it affects all policies attached to that interface. If a parameter value is changed for an interface, only the input, secondary-input, and output policies attached to that interface are affected by this change.

- If you modify a policy parameter value in Global Configuration mode, it affects all policies attached to all interfaces that use the global values. For example, if parameter param1 is used in policies attached to two interfaces, but param1 is only configured for interface i1, when you modify the default value for param1 in Global Configuration mode, it affects only the attachment on the second interface i2.

- You can specify a rate within a rate-limit profile as a percentage of the parameter and burst size in milliseconds. You can use this rate-limit profile in a policy. You can assign values to these parameters for an interface. The actual rate and burst size are calculated at the time of attachment. You can attach the same policy to multiple interfaces with different parameter values.

Policy Parameter Quick Configuration

To configure policing, use the following steps:

1. Configure a policy parameter in Global Configuration mode.

2. Assign the parameter type and global default value to a parameter.

3. Use this policy parameter in policy objects, create a generic policy, and attach it to multiple interfaces.

4. Adjust the policy parameter value for a specific interface by configuring it in Interface Configuration mode for any interface.

Creating Rate-Limit Profiles

Create rate-limit profiles with a rate based on percentage and a burst in milliseconds. The system creates a policy using these rate-limit profiles and then attaches them to different interfaces using different parameter values.

1. Create policy parameter refRlpRate.

   host1(config)#**policy-parameter refRlpRate reference-rate**
   host1(config-policy-param-reference-rate)#**reference-rate 100000**
   host1(config-policy-param-reference-rate)#**exit**

2. Create rate-limit profile rlpData.

   host1(config)#**ip rate-limit-profile rlpData**
   host1(config-rate-limit-profile)#**committed-rate refRlpRate percentage 10**
   host1(config-rate-limit-profile)#**committed-burst millisecond 100**
   host1(config-rate-limit-profile)#**peak-rate refRlpRate percentage 100**
   host1(config-rate-limit-profile)#**peak-burst millisecond 150**
   host1(config-rate-limit-profile)#**exit**

3. Create rate-limit profile rlpVoice.

   host1(config)#**ip rate-limit-profile rlpVoice**
   host1(config-rate-limit-profile)#**committed-rate 64000**
   host1(config-rate-limit-profile)#**committed-burst 100000**
   host1(config-rate-limit-profile)#**peak-rate refRlpRate percentage 100**

```
host1(config-rate-limit-profile)#peak-burst millisecond 150
host1(config-rate-limit-profile)#exit
```

4. Create rate-limit profile rlpVideo.

```
host1(config)#ip rate-limit-profile rlpVideo
host1(config-rate-limit-profile)#committed-rate refRlpRate percentage 70
host1(config-rate-limit-profile)#committed-burst millisecond 100
host1(config-rate-limit-profile)#peak-rate refRlpRate percentage 100
host1(config-rate-limit-profile)#peak-burst millisecond 150
host1(config-rate-limit-profile)#exit
```

5. Create the policy.

```
host1(config)#ip policy-list P
host1(config-policy)#classifier-group data
host1(config-policy-classifier-group)#rate-limit-profile rlpData
host1(config-policy-classifier-group)#exit
host1(config-policy)#classifier-group voice
host1(config-policy-classifier-group)#rate-limit-profile rlpVoice
host1(config-policy-classifier-group)#exit
host1(config-policy)#classifier-group video
host1(config-policy-classifier-group)#rate-limit-profile rlpVideo
host1(config-policy-classifier-group)#exit
host1(config-policy)#exit
```

6. Attach IP Policy P at interface atm5/0.1.

```
host1(config)#interface atm 5/0.1
host1(config-if)#ip policy-parameter reference-rate refRlpRate 1000000
host1(config-if)#ip policy input P
```

7. Attach IP Policy P at interface atm5/0.2 with merge.

```
host1(config)#interface atm 5/0.2
host1(config-if)#ip policy input P stats enabled merge
```

8. Display the policy list.

```
host1#show policy-list

Policy Table
------ -----
IP Policy P
   Administrative state: enable
   Reference count:      1
   Classifier control list: data, precedence 100
      rate-limit-profile rlpData
   Classifier control list: voice, precedence 100
      rate-limit-profile rlpVoice
   Classifier control list: video, precedence 100
      rate-limit-profile rlpVideo

   Referenced by interfaces:
      ATM5/0.1 input policy, statistics disabled, virtual-router default
      ATM5/0.2 input policy, statistics enabled, virtual-router default
```

```
   Referenced by profiles:
      None

   Referenced by merge policies:
      None
```

9. Display the rate-limit profiles.

```
host1#show rate-limit-profile

Rate Limit Profile Table
---- ----- ------- -----
IP Rate-Limit-Profile: rlpData
   Profile Type:                  two-rate
   Reference count:               1
   Committed rate:                refRlpRate % 10
   Committed burst:               100 milliseconds
   Peak rate:                     refRlpRate % 100
   Peak burst:                    150 milliseconds
   Mask:                          255
   Committed rate action:         transmit
   Conformed rate action:         transmit
   Exceeded rate action:          drop

IP Rate-Limit-Profile: rlpVoice
   Profile Type:                  two-rate
   Reference count:               1
   Committed rate:                64000
   Committed burst:               100000
   Peak rate:                     refRlpRate % 100
   Peak burst:                    150 milliseconds
   Mask:                          255
   Committed rate action:         transmit
   Conformed rate action:         transmit
   Exceeded rate action:          drop

IP Rate-Limit-Profile: rlpVideo
   Profile Type:                  two-rate
   Reference count:               1
   Committed rate:                refRlpRate % 70
   Committed burst:               100 milliseconds
   Peak rate:                     refRlpRate % 100
   Peak burst:                    150 milliseconds
   Mask:                          255
   Committed rate action:         transmit
   Conformed rate action:         transmit
   Exceeded rate action:          drop
```

10. Display policy parameters. If a rate-limit profile uses this parameter twice then it increases the reference count by 2.

```
host1#show policy-parameter brief
Reference-rate refRlpRate: 100000, 6 references

       Display policy parameters
host1#show policy-parameter
Policy Parameter refRlpRate
    Type: reference-rate
    Rate: 100000
    Reference count: 6
    Referenced by interfaces: 1 references
      IP interface ATM5/0.1: 1000000
```

```
    Referenced by rate-limit profiles: 5 references
      rlpData
      rlpVoice
      rlpVideo
```

11. Display interface atm5/0.1.

```
host1#show ip interface atm 5/0.1
ATM5/0.1 line protocol Atm1483 is down, ip is down (ready)
  Network Protocols: IP
  Internet address is 1.1.1.1/255.255.255.255
  Broadcast address is 255.255.255.255
  Operational MTU = 0  Administrative MTU = 0
  Operational speed = 100000000 Administrative speed = 0
  Discontinuity Time = 0
  Router advertisement = disabled
  Proxy Arp = disabled
  Network Address Translation is disabled
  TCP MSS Adjustment = disabled
  Administrative debounce-time = disabled
  Operational debounce-time    = disabled
  Access routing = disabled
  Multipath mode = hashed
  Auto Configure = disabled
  Auto Detect = disabled
  Inactivity Timer = disabled

  In Received Packets 0, Bytes 0
    Unicast Packets 0, Bytes 0
    Multicast Packets 0, Bytes 0
  In Policed Packets 0, Bytes 0
  In Error Packets 0
  In Invalid Source Address Packets 0
  In Discarded Packets 0
  Out Forwarded Packets 0, Bytes 0
    Unicast Packets 0, Bytes 0
    Multicast Routed Packets 0, Bytes 0
  Out Scheduler Dropped Packets 0, Bytes 0
  Out Policed Packets 0, Bytes 0
  Out Discarded Packets 0

  IP policy input P
    Statistics are disabled
```

12. Display interface atm5/0.2.

```
host1#show ip interface atm 5/0.2
ATM5/0.2 line protocol Atm1483 is down, ip is down (ready)
  Network Protocols: IP
  Internet address is 2.2.2.2/255.255.255.255
  Broadcast address is 255.255.255.255
  Operational MTU = 0  Administrative MTU = 0
  Operational speed = 100000000  Administrative speed = 0
  Discontinuity Time = 0
  Router advertisement = disabled
  Proxy Arp = disabled
  Network Address Translation is disabled
  TCP MSS Adjustment = disabled
  Administrative debounce-time = disabled
  Operational debounce-time    = disabled
  Access routing = disabled
  Multipath mode = hashed
```

```
Auto Configure = disabled
Auto Detect = disabled
Inactivity Timer = disabled

In Received Packets 0, Bytes 0
  Unicast Packets 0, Bytes 0
  Multicast Packets 0, Bytes 0
In Policed Packets 0, Bytes 0
In Error Packets 0
In Invalid Source Address Packets 0
In Discarded Packets 0
Out Forwarded Packets 0, Bytes 0
  Unicast Packets 0, Bytes 0
  Multicast Routed Packets 0, Bytes 0
Out Scheduler Dropped Packets 0, Bytes 0
Out Policed Packets 0, Bytes 0
Out Discarded Packets 0

IP policy input P
  classifier-group data entry 1
    0 packets, 0 bytes
    rate-limit-profile rlpData
         committed rate: 10000 bps, committed burst: 125 bytes
         peak Rate: 100000 bps, peak burst: 1875 bytes
      committed: 0 packets, 0 bytes, action: transmit
      conformed: 0 packets, 0 bytes, action: transmit
      exceeded:  0 packets, 0 bytes, action: drop
  classifier-group voice entry 1
    0 packets, 0 bytes
    rate-limit-profile rlpVoice
         committed rate: 64000 bps, committed burst: 100000 bytes
         peak Rate: 100000 bps, peak burst: 1875 bytes
      committed: 0 packets, 0 bytes, action: transmit
      conformed: 0 packets, 0 bytes, action: transmit
      exceeded:  0 packets, 0 bytes, action: drop
  classifier-group video entry 1
    0 packets, 0 bytes
    rate-limit-profile rlpVideo
         committed rate: 70000 bps, committed burst: 875 bytes
         peak Rate: 100000 bps, peak burst: 1875 bytes
      committed: 0 packets, 0 bytes, action: transmit
      conformed: 0 packets, 0 bytes, action: transmit
      exceeded:  0 packets, 0 bytes, action: drop
```

To configure a policy-parameter at an interface with the **increase** keyword:

1. Create policy list P2.

```
host1(config)#ip policy-list P2
host1(config-policy)#classifier-group data2
host1(config-policy-classifier-group)#rate-limit-profile rlpData
host1(config-policy-classifier-group)#exit
host1(config-policy)#exit
```

2. Attach IP Policy P2 at interface atm5/0.2 with the **merge** keyword.

```
host1(config)#interface atm 5/0.2
host1(config-lf)#ip policy-parameter reference-rate refRlpRate 100000
```

This increases from 0.

host1(config)#**ip policy-parameter reference-rate refRlpRate increase 100000**

This increases from the existing 100000.

host1(config)#**ip policy input P2 merge**

3. Verify the configuration.

```
host1#show policy-parameter
Policy Parameter refRlpRate
    Type: reference-rate
    Rate: 100000
    Reference count: 7
    Referenced by interfaces: 2 references
      IP interface ATM5/0.1: 1000000
      IP interface ATM5/0.2: 200000

    Referenced by rate-limit profiles: 5 references
      rlpData
      rlpVoice
      rlpVideo
```

One-Rate Rate-Limit Profiles Overview

E-series routers implement a single-rate rate limiter, which you can configure to provide more efficient service to TCP applications. With the single-rate rate limiter, when the committed rate is exceeded, the rate limiter drops a single packet and then resumes transmission up to a configurable burst window. The single, unacknowledged packet causes TCP to cut its transmission rate in half rather than falling back to its initial window size.

NOTE: Commands that you issue in Rate Limit Profile Configuration mode do not take effect until you exit from that mode.

The one-rate rate-limit profile attributes are:

- Color aware—Color-aware rate action (only for hierarchical rate limits)
- Committed rate—Target rate for a packet flow
- Committed burst—Amount of bandwidth allocated to accommodate bursty traffic in excess of the rate
- Excess burst—Amount of bandwidth allocated to accommodate a packet in progress when the rate is in excess of the burst
- Committed action—Drop, transmit, mark (IP and IPv6), or mark-exp (MPLS) when traffic flow does not exceed the rate; the mark value is not supported for hierarchical rate limits and the transmit values conditional, unconditional, or final are only supported on hierarchical rate limits

- Conformed action—Drop, transmit, mark (IP and IPv6), or mark-exp (MPLS) when traffic flow exceeds the rate but not the excess burst; the mark value is not supported for hierarchical rate limits and the transmit values conditional, unconditional, or final are only supported on hierarchical rate limits
- Exceeded action—Drop, transmit, mark (IP and IPv6), or mark-exp (MPLS) when traffic flow exceeds the rate; the mark value is not supported for hierarchical rate limits and the transmit values conditional, unconditional, or final are only supported on hierarchical rate limits
- Mask value—Mask to be applied with mark values for the ToS byte; applicable only to IP and IPv6 rate-limit profiles; not supported on hierarchical rate limits
- EXP mask value—Mask to be applied with mark-exp values; applicable only to MPLS rate-limit profiles; not supported on hierarchical rate limits

Creating a One-Rate Rate-Limit Profile

To create or modify a one-rate rate-limit profile, use the following commands with the **one-rate** keyword:

- **ip rate-limit-profile** command
- **ipv6 rate-limit-profile** command
- **l2tp rate-limit-profile** command
- **mpls rate-limit-profile** command

The following example creates a rate-limit profile named tcpFriendly8Mb. This rate-limit profile, when included as part of a rule in a policy list, sets a TCP-friendly rate for a specified flow:

```
host1(config)#ip rate-limit-profile tcpFriendly8Mb one-rate
host1(config-rate-limit-profile)#committed-rate 8000000
host1(config-rate-limit-profile)#committed-burst 1500000
host1(config-rate-limit-profile)#excess-burst 3000000
host1(config-rate-limit-profile)#committed-action transmit
host1(config-rate-limit-profile)#conformed-action transmit
host1(config-rate-limit-profile)#exceeded-action drop
host1(config-rate-limit-profile)#mask-val 255
```

To configure a single-rate hard limit, set the committed rate and burst rate to the desired values, the committed action to transmit, the conformed action to drop, and the exceeded action to drop. The peak rate must be set to zero.

NOTE: You can also achieve the characteristics of the single-rate hard limit by configuring a one-rate rate-limit profile with the extended burst rate set to zero.

Related Topics

- Rate Limits for Interfaces Overview on page 46
- *Chapter 9, Monitoring Policy Management*

Configuring a TCP-Friendly One-Rate Rate-Limit Profile

You can configure a committed rate, committed burst, and excess burst for the token bucket. For example, to configure a rate-limit process with hard tail dropping of packets when tokens are unavailable, set the committed rate and committed burst to a nonzero value, and set the excess burst to zero. Setting the excess burst to a nonzero value causes the router to drop packets in a more friendly way.

The configuration values for the preceding attributes determine the degree of friendliness of the rate-limit process. Instead of tail dropping packets that arrive outside the committed and burst rate envelope, the TCP-friendly bucket enables more tokens to be borrowed, up to a limit determined by the excess burst size. The next packet that borrows tokens in excess of the excess burst size is deemed excessive and is dropped if the exceeded action is set to drop.

The rate-limit algorithm is designed to avoid consecutive packet drops in the initial stages of congestion when the packet flow rate exceeds the committed rate of the token bucket. The intention is that just a few packet drops are sufficient for TCP's congestion control algorithm to drastically scale back its sending rate. Eventually, the packet flow rate falls below the committed rate, which enables the token bucket to replenish faster because of the reduced load.

If the packet flow rate exceeds the committed rate for an extended period of time, the rate-limit algorithm tends toward hard tail dropping. In a properly configured scenario, the rate limiter is consistently driven to borrow tokens because of TCP's aggressive nature, but it replenishes the tokens as TCP backs off, resulting in a delivered rate that is very close to the rate configured in the rate-limit profile.

The recommended burst sizes for TCP-friendly behavior are:

- Committed burst—0.2 to 2.0 seconds of the committed rate
- Excess burst—1.0 to 2.0 seconds of the committed rate, plus the committed burst

For example, if the committed rate is 1,000,000 bps, the recommended burst sizes are as follows:

- Committed burst is 1,000,000 x 1.0 x 1/8 = 125,000 bytes

  Multiplying the committed rate by 1.0 seconds converts the rate to bits, then multiplying the number of bits by 1/8 converts the value to bytes.

- Excess burst is 1,000,000 x 1.5 x 1/8 + 125,000 = 312,500 bytes

  Multiplying the committed rate by 1.5 converts the rate to bits, then multiplying the number of bits by 1/8 converts the value to bytes.

TCP-friendly rate limits have only one token bucket, but they also maintain a cumulative debt counter that represents how much traffic above the committed rate has recently been seen. This cumulative debt increases until it reaches the extended burst value; at that point the cumulative debt is reset to 0, but the offending packet is marked red. The cumulative debt increases faster than just by the packet size, so if the TCP source does not respond to TCP flow control and more of its packets are dropped.

Table 6 presents equations that can also represent the algorithm for the TCP-friendly one-rate rate limit profile when using hierarchical rate limiting, where:

- B = size of packet in bytes
- CD = cumulative debt
- t = time
- T(t) = number of tokens in token bucket at time t

Table 6: TCP-Friendly One-Rate Rate-Limit Profile Algorithms

Step	Result
If not color aware, use **green** as the incoming packet color, otherwise use the actual packet color	–
If incoming packet color is **green**	–
IF T(t) > = B	■ Packet is colored **green** ■ T(t) is decremented by B
If T(t) < B and CD is incremented by B – T(t)	–
If CD < Extended Burst and T(t) < B	■ Packet is colored **yellow** ■ T(t) is decremented by B (allow T(t) < 0, if necessary)
If CD > = Extended Burst B and T(t) < B	■ Packet is colored **red** ■ CD is reset to 0
If incoming packet color is **yellow** (only occurs in color-aware operation)	–
If T(t) < B and CD is incremented by B– T(t)	–
If CD < Extended Burst	■ Packet is colored **yellow** ■ T(t) is decremented by B (allow T(t) < 0, if necessary)
If CD > = Extended Burst	■ Packet is colored **red** ■ CD is reset to 0
If incoming packet color is **red** (only occurs in color-aware operation)	■ Packet is colored **red**

Two-Rate Rate-Limits Overview

The two-rate rate limiter enables you to build tiered rate-limit services and to specify different treatments for packets at different rates.

Token buckets control how many packets per second are accepted at each of the configured rates and provide flexibility in dealing with the bursty nature of data traffic. At the beginning of each sample period, the two buckets are filled with tokens based on the configured burst sizes and rates. Traffic is metered to measure its volume. When traffic is received, if tokens remain in both buckets, one token is removed from each bucket for every byte of data processed. As long as tokens are still in the committed burst bucket, the traffic is treated as committed.

When the committed burst token bucket is empty but tokens remain in the peak burst bucket, traffic is treated as conformed. When the peak burst token bucket is empty, traffic is treated as exceeded.

In color-blind mode, if the committed token bucket has enough tokens when a packet is received, the packet is green and tokens are subtracted from both the committed and the peak token buckets. If the peak bucket does not have enough tokens left, it is allowed to go negative. Green packets are the committed traffic.

If the committed bucket does not have enough tokens for the packet, the peak bucket is tested (and the committed bucket is not changed). If there are enough tokens in the peak bucket, it is decremented and the packet is yellow. Yellow packets are the conformed traffic. If the peak bucket does not have enough tokens either (because the committed bucket did not have enough tokens), the packet is red. Red packets are the exceeded traffic.

The two-rate rate-limit profile attributes are:

- ATM cell mode—ATM cell tax accounted for in statistics and rate calculations
- Color-aware—Color-aware rate action (only for hierarchical rate limits)
- Committed rate—Target rate for a packet flow
- Committed burst—Amount of bandwidth allocated to accommodate bursty traffic in excess of the committed rate
- Peak rate—Amount of bandwidth allocated to accommodate excess traffic flow over the committed rate
- Peak burst—Amount of bandwidth allocated to accommodate bursty traffic in excess of the peak rate
- Committed action—Drop, transmit, conditional, unconditional, final, mark (IP and IPv6), or mark-exp (MPLS) when traffic flow does not exceed the committed rate; the mark value is not supported for hierarchical rate limits and the transmit values conditional, unconditional, or final are only supported on hierarchical rate limits

- Conformed action—Drop, transmit, mark (IP and IPv6), or mark-exp (MPLS) when traffic flow exceeds the committed rate but remains below the peak rate; the mark value is not supported for hierarchical rate limits and the transmit values conditional, unconditional, or final are only supported on hierarchical rate limits

- Exceeded action—Drop, transmit, mark (IP and IPv6), or mark-exp (MPLS) when traffic flow exceeds the peak rate; the mark value is not supported for hierarchical rate limits and the transmit values conditional, unconditional, or final are only supported on hierarchical rate limits

- Mask value—Mask to be applied with mark values for the ToS byte; applicable only to IP and IPv6 rate-limit profiles; not supported on hierarchical rate limits

- EXP mask value—Mask to be applied with mark-exp values; applicable only to MPLS rate-limit profiles; not supported on hierarchical rate limits

Table 7 indicates the interaction between the rate settings and the actual traffic rate to determine the action taken by a rate-limit rule in a policy when applied to a traffic flow. This implementation is known as a *two-rate, three-color marking* mechanism.

Table 7: Policy Action Applied Based on Rate Settings and Traffic Rate

Peak Rate	Committed Rate = 0	Committed Rate Not 0
Peak rate = 0	■ All traffic assigned the exceeded action	■ Traffic < = committed rate assigned the committed action ■ Traffic > committed rate assigned the exceeded action
Peak rate not 0	■ Traffic < = peak rate assigned the conformed action ■ Traffic > peak rate assigned the exceeded action	■ Traffic < = committed rate assigned the committed action ■ Committed rate < Traffic < peak rate assigned the conformed action ■ Traffic > peak rate assigned the exceeded action

Table 8 presents equations that can represent the algorithm for the two-rate rate-limit profile, where:

- B = size of packet in bytes

- Tp = size of peak token bucket in bytes (maximum size of this bucket is the configured peak burst)

- Tc = size of the committed token bucket in bytes (maximum size of this bucket is the configured committed burst)

- t = time

Table 8: Two-Rate Rate-Limit Profile Algorithms

Step	Result
If not color-aware, use **green** as the incoming packet color, otherwise use the actual packet color	–
If incoming packet color is **green**:	–
If Tc(t) > = B	■ Packet is marked as **green** ■ Tc(t) is decremented by B ■ Tp(t) is decremented by B (allow Tp(t) < 0 if necessary)
If Tp(t) > = B and Tc(t) < B	■ Packet is marked as **yellow** ■ Tp(t) is decremented by B
If Tp(t) < B and Tc(t) < B	■ Packet is marked as **red**
If incoming packet color is **yellow** (only occurs in color-aware operation)	–
If Tp(t) > = B	■ Packet is marked as **yellow** ■ Tp(t) is decremented by B
If Tp(t) < B	■ Packet is marked as **red**
If incoming packet color is red (only occurs in color aware operation)	■ Packet is marked as **red**

Creating a Two-Rate Rate-Limit Profile

To create or modify a two-rate rate-limit profile, use the following commands with the **two-rate** keyword:

- rate-limit-profile command
- **ipv6 rate-limit-profile** command
- **mpls rate-limit-profile** command
- **l2tp rate-limit-profile** command

The following example creates a rate-limit profile named hardlimit9Mb. This rate-limit profile, when included as part of a rule in a policy list, sets a hard limit on the specified committed rate with no peak rate or peak burst ability:

```
host1(config)#ip rate-limit-profile hardlimit9Mb two-rate
host1(config-rate-limit-profile)#committed-rate 9000000
host1(config-rate-limit-profile)#committed-burst 20000
host1(config-rate-limit-profile)#committed-action transmit
host1(config-rate-limit-profile)#conformed-action drop
host1(config-rate-limit-profile)#exceeded-action drop
host1(config-rate-limit-profile)#mask-val 255
```

The following example modifies the rate-limit profile named hardlimit9Mb to include an exceeded action that marks the packets that exceed the peak rate. This marking action sets the DS field in the ToS byte (the six most significant bits) to the decimal value of 7 using a mask value of 0xFC:

```
host1(config)#ip rate-limit-profile hardlimit9Mb two-rate
host1(config-rate-limit-profile)#exceeded-action mark 7
host1(config-rate-limit-profile)#mask-val 252
```

To set IP precedence in the ToS byte, use the mask value of 0xE0, for visibility into the three most significant bits.

Related Topics

- Rate Limits for Interfaces Overview on page 46
- *Chapter 9, Monitoring Policy Management*

Setting the Committed Action for a Rate-Limit Profile

You can use the **committed-action** command to set the committed action for a rate-limit profile. Packets are colored green. For IP and IPv6 rate-limit profiles, mark the packet by setting the ToS byte (IP) or traffic class field (IPv6) to the specified 8-bit value, and transmit the packet. The mark value is masked with the default 255 unless it is overridden by the **mask-val** command to specify a different mask; not supported on hierarchical rate limits. For MPLS rate-limit profiles, set the EXP bits of MPLS packets to the specified value in the range 0–7, and transmit the packet. The mark EXP value is masked with the default 7 unless you use the **exp-mask** command to specify a different mask; not supported on hierarchical rate limits.The **no** version restores the default value, **transmit**.

To configure the committed action, enter Rate Limit Profile Configuration mode.

- Issue the **committed-action** command:

  ```
  host1(config-rate-limit-profile)#committed-action transmit
  ```

Related Topics

- **committed-action** command

Setting the Committed Burst for a Rate-Limit Profile

You can use the **committed-burst** command to set the committed burst in bytes; range is 1–4294967295. You can use the **committed-burst** command to set the committed burst in milliseconds for a rate-limit profile; range is 1–10000. The **no** version restores the default value, 8192 bytes if the rate is in bytes per second; 100 milliseconds if the rate is in milliseconds.

When you specify a nonzero value for the rate, the burst size is automatically calculated for a 100-ms burst as described for the **committed-rate** command. If the calculated burst size is less than the default value of 8 KB, the default value (8192 bytes) is used.

NOTE: We recommend that you do not configure a committed or peak burst size smaller than the MTU of the interface. Doing so causes large packets to be dropped even when they are transmitted at a very low rate.

When you specify a nonzero value for the committed rate, the committed burst size is calculated based on a 100-ms burst as follows:

committed burst in bytes = (committed rate in bps x 100 ms) ÷ 8 bits per byte

The router displays committed rate in bits per second and committed burst in bytes. For example, if the rate is 8 Mbps, the burst size is 100 ms x 8 Mbps = 800,000 bits or 100,000 bytes:

committed burst = (8,000,000 bps x 100 ms) ÷ 8 = 100,000 bytes

For this example, displaying the rate-limit profile shows:

committed-rate 8000000

committed-burst 100000

If the calculated burst value is less than the default burst size of 8 KB, the default burst size is used. For most configurations this value probably is sufficient, making it optional for you to configure a value for the associated committed burst size.

To configure the committed burst, enter Rate Limit Profile Configuration mode.

- Issue the **committed-burst** command:

  host1(config-rate-limit-profile)#**committed-burst 20000**

Related Topics

- **committed-burst** command

Setting the Committed Rate for a Rate-Limit Profile

You can set the committed rate as a percentage of a reference rate defined in the specified policy parameter.

- Issue the **committed-rate** command from Rate Limit Profile Configuration mode to set the committed rate in bits per second for a rate-limit profile:

  host1(config-rate-limit-profile)#**committed-rate refRlpRate percentage 10**

Related Topics

- **committed-rate** command

Setting the Conformed Action for a Rate-Limit Profile

You can use the **conformed-action** command. Packets are colored yellow.For IP and IPv6 rate-limit profiles, mark the packet by setting the ToS byte (IP) or traffic class field (IPv6) to the specified 8-bit value, and transmit the packet. The mark value is masked with the default 255 unless it is overridden by the **mask-val** command to specify a different mask; not supported on hierarchical rate limits.For MPLS rate-limit profiles, set the EXP bits of MPLS packets to the specified value in the range 0–7, and transmit the packet. The mark EXP value is masked with the default 7 unless you use the **exp-mask** command to specify a different mask; not supported on hierarchical rate limits.To set the conformed action for a rate-limit profile:

- Issue the **conformed-action** command from Rate Limit Profile Configuration mode:

  host1(config-rate-limit-profile)#**conformed-action transmit**

Related Topics

- **conformed-action** command

Setting the Exceeded Action for a Rate-Limit Profile

You can use the **exceeded-action** command to set the exceeded action for a rate-limit profile: Packets are colored red. For IP and IPv6 rate-limit profiles, mark the packet by setting the ToS byte (IP) or traffic class field (IPv6) to the specified 8-bit value, and transmit the packet. The mark value is masked with the default 255 unless it is overridden by the **mask-val** command to specify a different mask; not supported on hierarchical rate limits. For MPLS rate-limit profiles, set the EXP bits of MPLS packets to the specified value in the range 0–7, and transmit the packet.The mark EXP value is masked with the default 7 unless you use the **exp-mask** command to specify a different mask; not supported on hierarchical rate limits. The **no** version restores the default value, **drop.**

- Issue the **exceeded-action** command from Rate Limit Profile Configuration mode:

  host1(config-rate-limit-profile)#**exceeded-action drop**

Related Topics

- **exceeded-action** command

Setting the Excess Burst for a Rate-Limit Profile

For one-rate rate-limit profiles only, use the **excess-burst** command to set the excess burst in bytes for a rate-limit profile; range is 0–4294967295. Use the **excess-burst** command to set the excess burst in milliseconds for a rate-limit profile; range is 1–10000. The **no** version restores the default value, 0.

- Issue the excess-burst command from Rate Limit Profile Configuration mode:

  host1(config-rate-limit-profile)#**excess-burst millisecond 1000**

Related Topics

- **excess-burst** command

Setting the Mask Value for MPLS Rate-Limit Profiles

You can use the **exp-mask** command to set the mask value used for MPLS rate-limit profiles, in the range 1–255. The **no** version restores the default value, 7. This command is associated with the **committed-action, conformed-action,** and **exceeded-action** commands.

- Issue the **exp-mask** command from Rate Limit Profile Configuration mode.

  host1(config-rate-limit-profile)#**exp-mask 5**

Related Topics

- **mask-val** command

Setting the Mask Value for IP and IPv6 Rate-Limit Profiles

You can use the **mask-val** command to set the mask value used for IP and IPv6 rate-limit profiles. Use the mask values to set the appropriate bits in the ToS field of the IP packet header or in the traffic class field of the IPv6 packet header. The **no** version restores the default value, 255. This command is associated with the **committed-action, conformed-action.** and **exceeded-action** commands.

- Issue the **mask-val** command from Rate Limit Profile Configuration mode:

  host1(config-rate-limit-profile)#**mask-val 0xFC**

Related Topics

- **mask-val** command

Setting the Peak Burst for Two-Rate Rate-Limit Profiles

For two-rate rate-limit profiles only, you can use the **peak-burst** command to set the peak burst in bytes for a rate-limit profile; range is 1–4294967295. Use to set the peak burst in milliseconds for a rate-limit profile; range is 1–10000. The **no** version restore the default value, 100 ms or 8192 bytes (whichever is more).

When you specify a nonzero value for the peak rate, the peak burst size is automatically calculated for a 100-ms burst as described for the **peak-rate** command. If the calculated peak burst size is less than the default value of 8192 bytes, the default value is used.

NOTE: We recommend that you do not configure a committed or peak burst size smaller than the MTU of the interface. Doing so causes large packets to be dropped even when they are transmitted at a very low rate.

- Issue the **peak-burst** command in Rate Limit Profile Configuration mode to set the peak burst in bytes:

  host1(config-rate-limit-profile)#**peak-burst 96256**

  To set the peak burst in milliseconds:

  host1(config-rate-limit-profile)#**peak-burst millisecond 1000**

Related Topics

- **peak-burst** command

Setting the Peak Rate for Rate-Limit Profiles

For two-rate rate-limit profiles only, you can use the **peak-rate** command to set the peak rate in bits per second for a rate-limit profile; range is 1–4294967295. Use to set the peak rate as a percentage value; range is 0–100. During a software upgrade, the peak rate in a rate-limit profile is automatically set to 0 if it was nonzero but less than the committed rate before the upgrade. The **no** version to restores the default value, 0.

When you specify a nonzero value for the peak rate, the peak burst size is calculated based on a 100-ms burst as follows:

peak burst in bytes = (peak rate in bps x 100 ms) ÷ 8 bits per byte

The CLI displays peak rate in bits per second and peak burst in bytes. For example, if the rate is 8 Mbps, the burst size is 100 ms x 8 Mbps = 800,000 bits or 100,000 bytes:

peak burst = (8,000,000 bps x 100 ms) ÷ 8 = 100,000 bytes

For this example, displaying the rate-limit profile shows:

peak-rate 8000000
peak-burst 100000

If the calculated peak burst value is less than the default peak burst size of 8 KB, the default burst size is used. For most configurations this value is probably sufficient, making it optional to configure the associated peak burst size.

- Issue the **peak-rate** command in Rate Limit Profile Configuration mode to set the peak rate:

  host1(config-rate-limit-profile)#**peak-rate refRlpRate percentage 100**

Related Topics

- **peak-rate** command

Setting a One-Rate Rate-Limit Profile

You can use the **rate-limit-profile one-rate** command to create a rate-limit profile and enter Rate Limit Profile Configuration mode, from which you can configure attributes for the rate-limit profile. See Table 7 on page 72.

NOTE: The JUNOSe software includes the layer 2 headers in the calculations it uses to enforce the rates that you specify in rate-limit profiles.

Use one of the **ip**, **ipv6**, **l2tp**, or **mpls** keywords in front of the command to specify the type of rate-limit profile you want to create or modify. If you do not include one of the keywords, the router creates an IP rate-limit profile by default.

For hierarchical rate limits, do not specify the interface type, but add the **hierarchical** keyword at the end. The **color-aware** keyword is only supported on hierarchical rate limits.

If you do not include a **one-rate** or **two-rate** keyword, the default is a two-rate rate-limit profile. If you enter a **rate-limit-profile** command with the **one-rate** keyword and then type **exit**, the router creates a rate-limit profile with the default values listed in Table 9.

Table 9: One-Rate Rate-Limit-Profile Defaults

Policy Attribute	Default Value
type	one-rate
committed-rate	0
committed-burst	8192
excess-burst	0
committed-action	transmit
conformed-action	transmit
exceeded-action	drop
mask (IP and IPv6 rate-limit profiles)	255
exp-mask (MPLS rate-limit profiles)	7

NOTE: We recommend that you do not configure a committed or peak burst size smaller than the MTU of the interface. Doing so causes large packets to be dropped even when they are transmitted at a very low rate.

- Issue the **ip rate-limit-profile** command in Global Configuration mode:

  host1(config)#**ip rate-limit-profile tcpFriendly10Mb one-rate**

NOTE: Commands that you issue in Rate Limit Profile Configuration mode do not take effect until you exit from that mode.

Related Topics

- **rate-limit-profile** command

Setting a Two-Rate Rate-Limit-Profile

You can use the **rate-limit-profile tw0-rate** command to create a rate-limit profile and enter Rate Limit Profile Configuration mode, from which you can configure attributes for the rate-limit profile. See Table 7 on page 72.

NOTE: The JUNOSe software includes the layer 2 headers in the calculations it uses to enforce the rates that you specify in rate-limit profiles

Use one of the **ip**, **ipv6**, **l2tp**, or **mpls** keywords in front of the command to specify the type of rate-limit profile you want to create or modify. If you do not include one of the keywords, the router creates an IP rate-limit profile by default.

For hierarchical rate limits, do not specify the interface type, but add the **hierarchical** keyword at the end. In Parent Group Configuration Mode, associates a rate limit for a parent group. The **color-aware** keyword is only supported on hierarchical rate limits.

If you do not include a **one-rate** or **two-rate** keyword, the default is a two-rate rate-limit profile. If you enter a **rate-limit-profile** command and then type **exit**, the router creates a rate-limit profile with the default values listed in Table 10:

Table 10: Two-Rate Rate-Limit-Profile Defaults

Policy Attribute	Default Value
type	two-rate
committed-rate	0
committed-burst	8192
peak-rate	0
peak-burst	8192
committed-action	transmit
conformed-action	transmit
exceeded-action	drop
mask (IP and IPv6 rate-limit profiles)	255
exp-mask (MPLS rate-limit profiles)	7

During a software upgrade, certain values are set as follows:

- Committed burst size—Set to 8192 if it was less than that value before the upgrade
- Peak burst size—Set to 8192 if it was less than that value before the upgrade
- Peak rate—Set to 0 if it was nonzero but less than the committed rate before the upgrade

NOTE: We recommend that you do not configure a committed or peak burst size smaller than the MTU of the interface. Doing so causes large packets to be dropped even when they are transmitted at a very low rate.

- Issue the **ip rate-limit-profile** command in Global Configuration mode:

  host1(config)#**ip rate-limit-profile hardlimit9Mb two-rate**

NOTE: Commands that you issue in Rate Limit Profile Configuration mode do not take effect until you exit from that mode.

Related Topics

- **exp-mask** command
- **rate-limit-profile** command

Bandwidth Management Overview

When you configure the rate-limit profile, packets are tagged with a drop preference. The color-coded tag is added automatically when the committed and peak burst values for an interface's rate-limit profile are exceeded. The egress forwarding controller uses the drop preference to determine which packets are dropped when there is contention for outbound queuing resources within the E-series router.

The queuing system uses drop eligibility to select packets for dropping when congestion exists on an egress interface. This method is called *dynamic color-based threshold dropping*. The 2-bit tag assigns a color code to the packet: red, yellow, or green. Each packet queue has two color-based thresholds as well as a queue limit:

- Red packets are dropped when congestion causes the queue to fill above the red threshold.
- Yellow packets are dropped when the yellow threshold is reached.
- Green packets are dropped when the queue limit is reached.

This internal tagging is done automatically when a rate-limit profile is applied to an interface and does not necessarily reflect the operation of the policy on an interface.

Having a committed rate and a peak rate enables you to configure two different fill rates for the token buckets. For example, you can configure the fill rate on the peak token bucket to be faster than the fill rate on the committed bucket. This configuration enables you to accommodate bursts of traffic, but, through coloring, it enables you to identify which packets are committed and which ones are not.

To enforce ingress data rates below the physical line rate of a port, you can rate limit a classified packet flow at ingress. A rate-limit profile with a policy rate-limit profile rule provides this capability. The rate-limit profile defines the attributes of the desired rate.

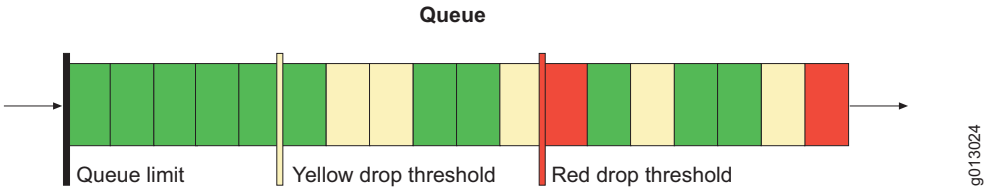
You can set an action based on one rate or two rates. These actions include drop, transmit, or mark. The default is to transmit committed and conformed packets, and to drop exceeded packets.

A color-coded tag is added automatically to each packet based on the following categories:

- Committed—Green
- Conformed—Yellow
- Exceeded—Red

Figure 6 illustrates congestion management.

Figure 6: Congestion Management



One-Rate Rate-Limit Profile Examples

A one-rate rate-limit profile can be configured for hard tail drop rate-limit or TCP-friendly behavior. Packets can be categorized as committed, conformed, or exceeded.

You can configure a one-rate rate-limit profile to hard limit a packet flow to a specified rate. To rate limit the traffic on an interface from source IP address 1.1.1.1 to 1 Mbps, issue the following commands:

host1#**configure terminal**
host1(config)#**ip rate-limit-profile oneMegRlp one-rate**
host1(config-rate-limit-profile)#**committed-rate 1000000**
host1(config-rate-limit-profile)#**exit**

host1(config)#**ip classifier-list clacIA ip host 1.1.1.1 any**
host1(config)#**ip policy-list testPolicy**
host1(config-policy-list)#**classifier-group clacIA**
host1(config-policy-list-classifier-group)#**rate-limit-profile oneMegRlp**
host1(config-policy-list-classifier-group)#**exit**
host1(config-policy-list)#**exit**

host1(config)#**interface atm 0/0.0**
host1(config-subif)#**ip policy input testPolicy statistics enabled**

You can also configure a one-rate rate-limit profile to provide a TCP-friendly rate limiter. To configure a rate limiter with TCP-friendly characteristics, we recommend that you set the committed burst to allow for 1 second of data at the specified rate, and the excess burst to allow 1.5 seconds of data at the specified committed rate plus the committed burst. For example:

host1(config)#**ip rate-limit-profile tcpFriendly8MB one-rate**
host1(config-rate-limit-profile)#**committed-rate 8000000**
host1(config-rate-limit-profile)#**committed-burst 1000000**
host1(config-rate-limit-profile)#**excess-burst 2500000**
host1(config-rate-limit-profile)#**committed-action transmit**
host1(config-rate-limit-profile)#**exceeded-action drop**

Two-Rate Rate-Limit Profile Examples

You can configure a two-rate rate-limit profile for two different rates, committed and peak, that are used to define a two-rate, three-color marking mechanism. You can categorize packets as committed, conformed, or exceeded:

- Up to the committed rate, packets are considered to be committed.
- From the committed to peak rate, packets are considered to be conformed.
- After the peak rate, packets are considered to be exceeded.

This configuration is implemented with token buckets. See RFC 2698 for more details.

The following example rate limits traffic on an interface from source IP address 1.1.1.1 so that traffic at a rate up to 1 Mbps is colored green and transmitted, traffic at a rate from 1 Mbps to 2 Mbps is colored yellow and transmitted, and traffic at a rate above 2 Mbps is dropped.

```
host1(config)#ip rate-limit-profile 1MbRLP
host1(config-rate-limit-profile)#committed-rate 1000000
host1(config-rate-limit-profile)#peak-rate 2000000
host1(config-rate-limit-profile)#committed-action transmit
host1(config-rate-limit-profile)#conformed-action transmit
host1(config-rate-limit-profile)#exceeded-action drop
host1(config-rate-limit-profile)#exit

host1(config)#ip classifier-list clacIA ip host 1.1.1.1 any
host1(config)#ip policy-list testPolicy
host1(config-policy-list)#classifier-group clacIA
host1(config-policy-list-classifier-group)#rate-limit-profile 1MbRLP
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit

host1(config)#interface atm 0/0.0
host1(config-subif)#ip policy input testPolicy statistics enabled
```

Rate-Limiting Individual or Aggregate Packet Flows Examples

You can construct policies to provide rate limiting for individual packet flows or for the aggregate of multiple packet flows. For example, if you have traffic from multiple sources, you can either rate limit each traffic flow individually, or you can rate limit the aggregate flow for the traffic from all sources.

- To rate limit individual packet flows, use a separate classifier list to classify each flow. See In the following example, interface ATM 3/1.1 classifies on three traffic flows from different sources. Each traffic flow is rate limited to 1MB (which is defined by the rate-limit profile rl1Meg).
- To rate limit the aggregate of multiple traffic flows, use a single classifier list for the multiple entries.

In the following example, interface ATM 3/1.1 classifies on three traffic flows from different sources. Each traffic flow is rate limited to 1MB (which is defined by the rate-limit profile rl1Meg).

```
host1(config)#ip classifier-list clFlow1 ip host 10.1.1.1 any
host1(config)#ip classifier-list clFlow2 ip host 10.1.1.2 any
host1(config)#ip classifier-list clFlow3 ip host 10.1.1.3 any
host1(config)#ip policy-list plRateLimit
host1(config-policy-list)#classifier-group clFlow1
host1(config-policy-list-classifier-group)#rate-limit-profile rl1Meg
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group clFlow2
host1(config-policy-list-classifier-group)#rate-limit-profile rl1Meg
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group clFlow3
host1(config-policy-list-classifier-group)#rate-limit-profile rl1Meg
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
host1(config)#interface atm 3/1.1
host1(config-subif)#ip policy input plRateLimit statistics enabled
host1(config-subif)#exit
```

In the following example, interface ATM 3/1.1 again classifies on three traffic flows; however, this policy rate limits the aggregate of the three flows to 1 MB.

```
host1(config)#ip classifier-list clFlowAll ip host 10.1.1.1 any
host1(config)#ip classifier-list clFlowAll ip host 10.1.1.2 any
host1(config)#ip classifier-list clFlowAll ip host 10.1.1.3 any
host1(config)#ip policy-list plRateLimit
host1(config-policy-list)#classifier-group clFlowAll
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
host1(config)#interface atm 3/1.1
host1(config-subif)#ip policy input plRateLimit statistics enabled
host1(config-subif)#exit
```

Rate-Limiting SRP Traffic Flows

You can rate limit traffic flows destined for an SRP module by implementing a token bucket policer. The configured rate limits are stored in NVS and persist across reboots.

Related Topics

- Rate Limits for Interfaces Overview on page 46
- *Chapter 9, Monitoring Policy Management*
- **control-plane** command
- **policer** command

Chapter 6

Merging Policies

This chapter provides information about merging policies on E-series routers. The chapter discusses the following topics:

Merging Policies Overview

Merging policies enables you to create multiple policy attachments at an attachment point, resulting in a merged policy that is created and attached at this interface. Executing more than one policy attachment command with the same attachment type at an interface triggers a policy merge through the CLI.

In Profile Configuration mode, policy interface commands for IP and L2TP allow attachments to be merged into any existing merge-capable attachment at an attachment point. Service Manager can request that multiple interface profiles be applied or removed at an interface as part of service activation or deactivation. Service Manager also specifies whether or not the attachments created from these interface profiles are persistent on subsequent reloads.

An interface and an attachment type identify an attachment point. The policies referenced by the component attachments merge into a new policy, which then attaches at the attachment point. The set of component policies are ordered alphabetically by name. This order determines how any merge conflicts are resolved, with the most recently executed command taking precedence.

With policy merging, a set of policies is combined to form a single new policy, which is a union of all the component policies. Classifier groups and policy rules from each component combine to create the merged policy as in the following example:

```
host1(config)#interface atm 5/0.1
host1(config-subif)#ip policy input p1 statistics enable merge
host1(config-subif)#ip policy input p2 statistics enable merge
host1(config-subif)#ip policy input p3 statistics enable merge
host1(config-subif)#ip policy output p4 statistics enable merge
host1(config-subif)#ip policy output p5 statistics enable merge
host1(config-subif)#exit
```

The example internally results in the following, where policies p1 + p2 + p3 = mpl_10 and policies p4 + p5 = mpl_11.

```
interface atm 5/0.1
ip policy input mpl_10 statistics enable merge
ip policy output mpl_11 statistics enable merge
exit
```

The classifier list referenced by the classifier group is neither split or merged. If a merged policy already exists for a set of component policies, then the merged policy is used for the attachment. An attachment enables a merged policy to have one or more attachments.

Policy Merging Rules for Attachment Through Interface Configuration Mode

The CLI and the Service Manager applications are the only clients of policy management that can request merging of policy attachments. With policy merging, classifier groups and policy rules from each component policy combine into the merged policy.

Policy merging follows these rules:

- The Classifier list referenced by the classifier group cannot be split or merged.
- Policy merging combines classifier groups from all component policies into the merged policy. In the previous example, policies p1, p2, and p3 are the component policies and mpl_10 is the merged policy. The merge policy is created as if all CLI commands for each component policy are run in the context of the merged policy. The merged policy result is the sum of all commands executed in the respective component policies CLI context in a predetermined merge order.
- If a merged policy already exists for a set of component policies, the merged policy is used for the attachment instead of creating a new one. This functionality allows a merged policy to have one or more attachments. A merge policy is automatically deleted when the last reference is removed.

Policy Merging Restrictions

The following restrictions apply to policy merging:

- Classifier lists cannot be merged.
- Secure policies cannot be merged.
- Policies created using ascend-data-filters cannot be merged.
- Existing policy VSAs in RADIUS are not changed; attachments created by this method cannot be merged. Ascend data filter policies can be attached at input and output attachment points.
- SNMP support for polling statistics based on component policy attachments is not available.
- The merge policy naming convention is not configurable.

Resolving Policy Merge Conflicts

The set of component policies are first ordered by their name to form the final merged policy. For example, if the component policies sets contain cp_1, cp_3, cp_9, cp_2, the order in which these policies are merged is cp_1, cp_2, cp_3, and cp_9. The merge order is important for resolving merge conflicts.

Various conflicting combinations of component policies can result in a merged policy that is not a perfect union of the component policies. These conflicts are resolved as they currently are in policy CLI context, where, in any conflict, the most recently executed command takes precedence.

More than one component policy can contain the same classifier group. If the precedence does not match, the precedence of the classifier group defined in the last component policy becomes the final precedence for this classifier group in the merged policy, as in the following example:

```
host1(config)#ip policy-list p1
host1(config-policy)#classifier-group C1 precedence 90
host1(config-classifier-group)#forward
host1(config-classifier-group)#exit
host1(config)#ip policy-list p2
host1(config-policy)#classifier-group C1 precedence 100
host1(config-classifier-group)#forward
host1(config-classifier-group)#exit
host1(config)#ip policy-list p3
host1(config-policy)#classifier-group C1 precedence 130
host1(config-classifier-group)#forward
host1(config-classifier-group)#exit
```

If you combine p1, p2, and p3, you get the following with p1, p2, p3 as the merge order for the set of component policies.

```
ip policy-list mpl_10
classifier-group C1 precedence 130
forward
exit
```

For IP, the forward, filter, next-hop, and next-interface rules are mutually exclusive within a classifier group. For all other types, filter and forward rules are mutually exclusive.

A conflict arises when more than one component policy has the same classifier group and when the rule sets defined in these classifier groups conflict. To resolve the merge conflict, the last command entered replaces any previous conflicting commands for a classifier group, as in the following example:

```
host1(config)#ip policy-list p1
host1(config-policy)#classifier-group C1 precedence 90
host1(config-classifier-group)#forward
host1(config-classifier-group)#exit
host1(config)#ip policy-list p2
host1(config-policy)#classifier-group C1 precedence 90
host1(config-classifier-group)#next-hop 1.1.1.1
host1(config-classifier-group)#exit
host1(config)#ip policy-list p3
host1(config-policy)#classifier-group C1 precedence 90
host1(config-classifier-group)#filter
host1(config-classifier-group)#exit
```

Combining p1 and p2 internally results in:

```
ip policy-list mpl_20
classifier-group C1 precedence 90
next-hop 1.1.1.1
exit
```

Combining p2 and p3 internally results in:

```
ip policy-list mpl_21
classifier-group C1 precedence 90
filter
exit
```

Combining p1, p2, and p3 internally results in:

ip policy-list mpl_22

classifier-group C1 precedence 90
filter
exit

If you have the same policy rule with different parameters, the parameter of the last rule entered with the same type is used, with the exception of IP forward rule, to resolve the conflict, as in the following example:

host1(config)#**ip policy-list p1**
host1(config-policy)#**classifier-group C1 precedence 90**
host1(config-classifier-group)#**color red**
host1(config-classifier-group)#**exit**
host1(config)#**ip policy-list p2**
host1(config-policy)#**classifier-group C1 precedence 90**
host1(config-classifier-group)#**color yellow**
host1(config-classifier-group)#**exit**

Combining p1 and p2 internally results in:

ip policy-list mpl_20
classifier-group C1 precedence 90
color yellow
exit

With the IP policy forward rule, when more forward rules are added to an existing classifier group, the list of forward rules is created. This is also true during merging, as in the following example:

host1(config)#**ip policy-list p1**
host1(config-policy)#**classifier-group C1 precedence 90**
host1(config-classifier-group)#**forward next-hop 1.1.1.1**
host1(config-classifier-group)#**exit**
host1(config)#**ip policy-list p2**
host1(config-policy)#**classifier-group C1 precedence 90**
host1(config-classifier-group)#**forward next-interface atm 5/0.1**
host1(config-classifier-group)#**exit**
host1(config)#**ip policy-list p2**
host1(config-policy)#**classifier-group C1 precedence 90**
host1(config-classifier-group)#**forward next-interface fastEthernet 4/0.1 next-hop 1.1.1.2**
host1(config-classifier-group)#**exit**

Combining p1, p2, and p3, internally results in the following:

ip policy-list mpl_10
classifier-group C1 precedence 90
forward next-hop 1.1.1.1
forward next-interface atm 5/0.1
forward next-interface fastEthernet 4/0.1 next-hop 1.1.1.2
exit

Policy management enables multiple policy attachments at the same attachment point, which results in a merged policy that is created and attached at the specified attachment point. The logical OR of the **statistics** and **baseline** keywords of all attachments are used as the **statistics** and **baseline** keyword for the merged policy attachment, as in the following example:

```
host1(config)#interface atm 5/0.1
host1(config-subif)#ip policy input p1 statistics enable baseline enable merge
host1(config-subif)#ip policy input p2 merge
host1(config-subif)#ip policy input p3 statistics enable merge
host1(config-subif)#exit
```

Results in the following:

```
interface atm 5/0.1
ip policy input mpl_5 statistics enable baseline enable merge
exit
```

Merged Policy Naming Conventions

Merged policies are dynamically created. The naming convention is mpl_*hex_of internally_generated_policy ID*, such as mpl_10. If the newly generated name already exists, then a sequence number is appended to the new name to make it unique. The sequence number starts at 1 and increments until the name is unique, such as mpl_10_2.

Reference Counting for Merged Policies

The reference counts in all containers referenced within a merged policy are incremented by the number of times they are referenced within the merged policy. Also, the reference counts of all component policies of a merged policy are incremented because of the association of the component policies with the merged policy. This means you cannot delete a component policy while a merged policy is still associated with it.

Persistent Configuration Differences for Merged Policies Through Service Manager

Service Manager can specify whether a component policy attachment is nonvolatile. If the interface where the component policy is attached is volatile, then policy management makes the attachment volatile even when the Service Manager specifies otherwise. A nonvolatile interface can have both volatile and nonvolatile component policy attachments. The merged policy that is created is the merge of all component policies attached at a given attachment point regardless of their volatility. The merged policy and its attachments are always volatile and reconstructed on each reload operation.

Policy Attachment Sequence at Login Through Service Manager

During a user login, you can specify policy attachments through Service Manager, RADIUS, and Interface Profile. The order that is used to select the policy attachment source is Service Manager, RADIUS, and Interface Profile.

For example, if you configure Ingress-Policy-Name VSA for a user in RADIUS and also have a profile with an input policy reference applied to this user's interface column, when the user logs in, the RADIUS VSA is selected as the source for the input policy attachment. If you also have service profiles applied to the user's interface column, the service profiles override both RADIUS VSA and the policy name specified in the interface profile.

NOTE: Policy merging is not supported with ascend data filter policies.

Policy management does not reselect the source if the policy attachment fails for the selected source. If the policy attachment via service profiles fails, policy management does not reselect RADIUS VSA as the next source. This means the interface does not have any input policy attachment.

Policy Attachment Rules for Merged Policies

The attributes of a policy attachment are as follows:

- Policy name—Name of policy to be attached.
- Attachment type—Type of attachment.
- Statistics enable/disable—Enable or disable statistics for the attachment.
- Baseline enable/disable—Enable or disable baselining for the attachment.
- Merge or Replace—Allow an attachment to become merge-capable and merge with any other attachments that are merge-capable. If the **merge** keyword is not specified, then it replaces any existing attachments with the new attachment. Merging always preserves statistics.
- Preserve—Preserve statistics from earlier attachment when replacing an attachment. This keyword is mutually exclusive with **merge** keyword.

Various possibilities result from a policy attachment at an interface due to the presence or absence of these keywords. The same rules apply while attaching policies based on interface profiles provided by Service Manager except as noted.

Attachments made through Interface Configuration mode follow these rules:

- If an attachment is issued with the **merge** keyword specified:
  - Any existing attachment of the same type at the interface without the **merge** keyword is replaced by the new attachment, which then becomes merge-capable.
  - An attachment is merged with any existing attachments of the same type that have the **merge** keyword set. If a merged policy already exists for the set of component policies, then this merged policy is used or a new merged policy is created dynamically and attached. The statistics for common classifier groups are preserved when replacing the existing merged attachment.
- If an attachment is issued when no **merge** or **preserve** keyword is set, then it replaces all other attachments with the same type at the interface. This attachment is not merge-capable for future use and statistics from previous attachments are not preserved.
- If an attachment is issued when the **merge** keyword is not set, but the **preserve** keyword is set, it replaces all other attachments with the same type at the interface. This attachment is not merge-capable for future use. Statistics from existing attachments are preserved for all the common classifier-groups.
- You cannot have multiple attachments of the same policy on a single attachment point. Only Service Manager executes multiple attachments of the same policy at the same attachment point.
- A detachment based on the policy name removes all attachments for that policy at the specified attachment point in a single command regardless of creation source. A detachment based on attachment type detaches all attachments at that attachment point regardless of creation source. Service Manager can delete only one attachment at a time through service deactivation.
- The **statistics** and **baseline** keywords for the merged policy attachment are computed as a logical OR for all attachments at the specified attachment point.
- If you delete an attachment:
  - The merged policy is recomputed with the remaining attachments of the same type that have the **merge** keyword set. The statistics for common classifier groups are preserved when replacing the existing merged attachment.
  - The **statistics** and **baseline** keywords for the merged policy attachment are recomputed to be a logical OR of all remaining attachments at the specified attachment point.

Error Conditions for Merged Policies

Most errors, such as mismatched interface types while merging attachments, are caught during configuration. If merging fails, the attachment at the given interface is not modified.

You can modify component policies manually. Although you might want to do this for debugging purposes, we highly discourage you doing this because it can affect synchronization with the Service Manager application. You cannot manually attach a final merged policy to any interfaces. Instead, attach the set of component policies that constitute this merged policy. If you want to modify the final merged policy, use existing policy merging or component policy modification to achieve this.

Merging Policies Configuration

In the following example IP policy p1 and IP policy p2 are attached at interface atm5/0.1 as input attachments. Subsequently, policy p3 is attached at the same point. Then policies p1 and p2 are attached as output at atm 5/0.2.

1. Create IP policy p1.

```
host1(config)#ip classifier-list C1 tcp host 1.1.1.1 any eq 80
host1(config)#ip classifier-list C2 icmp any any 8 0
host1(config)#ip policy-list p1
host1(config-policy)#classifier-group C1 precedence 90
host1(config-policy-classifier-group)#forward next-hop 10.1.1.1
host1(config-policy-classifier-group)#exit
host1(config-policy)#classifier-group C2 precedence 10
host1(config-policy-classifier-group)#filter
host1(config-policy-classifier-group)#exit
```

2. Create IP policy p2.

```
host1(config)#ip classifier-list C1 tcp host 1.1.1.1 any eq 80
host1(config)#ip classifier-list C3 ip any host 2.2.2.2
host1(config)#ip policy-list p2
host1(config-policy)#classifier-group C1 precedence 90
host1(config-policy-classifier-group)#forward next-hop 20.1.1.1
host1(config-policy-classifier-group)#exit
host1(config-policy)#classifier-group C3 precedence 10
host1(config-policy-classifier-group)#filter
host1(config-policy-classifier-group)#exit
host1(config-policy)#classifier-group * precedence 1000
host1(config-policy-classifier-group)#forward
host1(config-policy-classifier-group)#exit
```

3. Attach IP policy p1 as input at interface atm5/0.1.

```
host1(config)#Interface atm 5/0.1
host1(config-subif)#ip policy input p1 statistics enable merge
host1(config-subif)#exit
```

4. Attach IP policy p2 as input at interface atm 5/0.1. A merged policy is created.

```
host1(config)#Interface atm 5/0.1
host1(config-subif)#ip policy input p2 statistics enable merge
host1(config-subif)#exit
```

5. Display the policy lists.

```
host1#show policy-list

                                  Policy Table
                                  ------ -----
IP Policy p1
   Administrative state: enable
   Reference count:      1
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)

   Referenced by interfaces:
      None

   Referenced by profiles:
      None

   Referenced by merge policies:
      mpl_5

IP Policy p2
   Administrative state: enable
   Reference count:      1
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 20.1.1.1, order 100, rule 3 (active)
   Classifier control list: *, precedence 1000
      forward

   Referenced by interfaces:
      None

   Referenced by profiles:
      None

   Referenced by merge policies:
      mpl_5

IP Policy mpl_5
   Administrative state: enable
   Reference count:      1
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: C1, precedence 90
```

```
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)
           next-hop 20.1.1.1, order 100, rule 3 (reachable)
   Classifier control list: *, precedence 1000
      forward

   Referenced by interfaces:
      ATM5/0.1  input policy, statistics enabled, virtual-router default

   Referenced by profiles:
      None

   Component policies:
      p1
      p2
```

6. Show configuration.

```
host1#show conf

! Configuration script being generated on TUE APR 26 2005 17:33:01 UTC
! Juniper Edge Routing Switch ERX-1440
! Version: 9.9.9 development-4.0 (April 4, 2005  15:39)
! Copyright (c) 1999-2005 Juniper Networks, Inc.  All rights reserved.
!
! Commands displayed are limited to those available at privilege level 15
!
…
interface atm 5/0.1
 ip policy input p1 statistics enabled merge
 ip policy input p2 statistics enabled merge
 exit
…
…
ip policy-list p1
 classifier-group C2 precedence 10
  filter
 classifier-group C1 precedence 90
  forward next-hop 10.1.1.1
!
ip policy-list p2
 classifier-group C3 precedence 10
  filter
 classifier-group C1 precedence 90
  forward next-hop 20.1.1.1
 classifier-group * precedence 1000
  forward
!
…
…
! End of generated configuration script.
```

7. Display interface statistics.

```
host1#show ip interface atm 5/0.1

ATM5/0.1 line protocol Atm1483 is up, ip is up
  Network Protocols: IP
  Internet address is 99.99.99.2/255.255.255.0
  Broadcast address is 255.255.255.255
```

```
Operational MTU = 9180  Administrative MTU = 0
Operational speed = 155520000  Administrative speed = 0
Discontinuity Time = 721112
Router advertisement = disabled
Proxy Arp = disabled
Network Address Translation is disabled
TCP MSS Adjustment = disabled
Administrative debounce-time = disabled
Operational debounce-time    = disabled
Access routing = disabled
Multipath mode = hashed
Auto Configure = disabled
Auto Detect = disabled
Inactivity Timer = disabled

In Received Packets 0, Bytes 0
  Unicast Packets 0, Bytes 0
  Multicast Packets 0, Bytes 0
In Policed Packets 0, Bytes 0
In Error Packets 0
In Invalid Source Address Packets 0
In Discarded Packets 0
Out Forwarded Packets 0, Bytes 0
  Unicast Packets 0, Bytes 0
  Multicast Routed Packets 0, Bytes 0
Out Scheduler Dropped Packets 0, Bytes 0
Out Policed Packets 0, Bytes 0
Out Discarded Packets 0

IP policy input mpl_5
  classifier-group C2 entry 1
    0 packets, 0 bytes
    filter
  classifier-group C3 entry 1
    0 packets, 0 bytes
    filter
  classifier-group C1 entry 1
    0 packets, 0 bytes
    forward
  classifier-group *
    0 packets, 0 bytes
    forward
queue 0: traffic class best-effort, bound to ip ATM5/0.1
  Queue length 0 bytes
  Forwarded packets 0, bytes 0
  Dropped committed packets 0, bytes 0
  Dropped conformed packets 0, bytes 0
  Dropped exceeded packets 0, bytes 0
```

8. Attach IP policy p1 at atm 5/0.2 as output.

   host1(config)#**interface atm 5/0.2**
   host1(config-subif)#**ip policy output p1 statistics enable merge**
   host1(config-subif)#**exit**

9. Attach IP policy p2 at atm 5/0.2 as output. Merge policy mpl_5 is now attached.

   host1(config)#**interface atm 5/0.2**
   host1(config-subif)#**ip policy output p2 merge**
   host1(config-subif)#**exit**

10. Display policies to verify that mpl_5 is created.

```
host1#show policy-list

                                    Policy Table
                                    ------ -----
IP Policy p1
   Administrative state: enable
   Reference count:      1
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)

   Referenced by interfaces:
      None

   Referenced by profiles:
      None

   Referenced by merge policies:
      mpl_5

IP Policy p2
   Administrative state: enable
   Reference count:      1
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 20.1.1.1, order 100, rule 3 (active)
   Classifier control list: *, precedence 1000
      forward

   Referenced by interfaces:
      None

   Referenced by profiles:
      None

   Referenced by merge policies:
      mpl_5

IP Policy mpl_5
   Administrative state: enable
   Reference count:      2
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)
           next-hop 20.1.1.1, order 100, rule 3 (reachable)
   Classifier control list: *, precedence 1000
      forward
```

```
   Referenced by interfaces:
      ATM5/0.1  input policy, statistics enabled, virtual-router default
      ATM5/0.2  output policy, statistics enabled, virtual-router default

   Referenced by profiles:
      None

   Component policies:
      p1
      p2
```

11. Create and attach IP policy p3 at atm 5/0.1. A new merge policy mpl_7 is created, which is a combination of p1, p2, and p3. The previous merge policy attachment is removed.

```
host1(config)#ip classifier-list C4 udp host 1.1.1.1 any eq 900
host1(config)#ip policy-list p3
host1(config-policy)#classifier-group C4 precedence 900
host1(config-policy-classifier-group)#color red
host1(config-policy-classifier-group)#exit
host1(config-policy)#classifier-group C1 precedence 80
host1(config-policy-classifier-group)#color yellow
host1(config-policy-classifier-group)#exit
host1(config-policy)#exit
host1(config)#interface atm 5/0.1
host1(config-subif)#ip policy input p3 statistics enable merge
host1(config-subif)#exit
```

12. Display policies to verify that mpl_5 and mpl_7 have been created.

```
host1#show policy-list

                                  Policy Table
                                  ------ -----
IP Policy p1
   Administrative state: enable
   Reference count:      2
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)

   Referenced by interfaces:
      None

   Referenced by profiles:
      None

   Referenced by merge policies:
      mpl_5
      mpl_7

IP Policy p2
   Administrative state: enable
   Reference count:      2
   Classifier control list: C3, precedence 10
      filter
```

```
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 20.1.1.1, order 100, rule 3 (active)
   Classifier control list: *, precedence 1000
      forward

   Referenced by interfaces:
      None

   Referenced by profiles:
      None

   Referenced by merge policies:
      mpl_5
      mpl_7

IP Policy p3
   Administrative state: enable
   Reference count:      1
   Classifier control list: C1, precedence 80
      color yellow
   Classifier control list: C4, precedence 900
      color red

   Referenced by interfaces:
      None

   Referenced by profiles:
      None

   Referenced by merge policies:
      mpl_7

IP Policy mpl_5
   Administrative state: enable
   Reference count:      1
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)
           next-hop 20.1.1.1, order 100, rule 3 (reachable)
   Classifier control list: *, precedence 1000
      forward

   Referenced by interfaces:
      ATM5/0.2  output policy, statistics enabled, virtual-router default

   Referenced by profiles:
      None

   Component policies:
      p1
      p2

IP Policy mpl_7
   Administrative state: enable
```

```
   Reference count:      1
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: C1, precedence 80
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)
           next-hop 20.1.1.1, order 100, rule 3 (reachable)
      color yellow
   Classifier control list: C4, precedence 900
      color red
   Classifier control list: *, precedence 1000
      forward

   Referenced by interfaces:
      ATM5/0.1  input policy, statistics enabled, virtual-router default

   Referenced by profiles:
      None

   Component policies:
      p1
      p2
      p3
```

13. Detach p2 from atm 5/0.1. A new merge policy mpl_8 is created, which is a combination of p1 and p3. The previous merge policy mpl_7 is detached and, because this policy has no attachments, it is deleted.

```
host1(config)#interface atm 5/0.1
host1(config-subif)#no ip policy input p2
host1(config-subif)#exit
```

14. Display policies to verify that the mpl_7 is removed and the new merge policy mpl_8 is created.

```
host1#show policy-list

                                  Policy Table
                                  ------ -----
IP Policy p1
   Administrative state: enable
   Reference count:      2
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)

   Referenced by interfaces:
      None

   Referenced by profiles:
      None
```

```
   Referenced by merge policies:
      mpl_5
      mpl_8

IP Policy p2
   Administrative state: enable
   Reference count:      1
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 20.1.1.1, order 100, rule 3 (active)
   Classifier control list: *, precedence 1000
      forward

   Referenced by interfaces:
      None

   Referenced by profiles:
      None

   Referenced by merge policies:
      mpl_5

IP Policy p3
   Administrative state: enable
   Reference count:      1
   Classifier control list: C1, precedence 80
      color yellow
   Classifier control list: C4, precedence 900
      color red

   Referenced by interfaces:
      None

   Referenced by profiles:
      None

   Referenced by merge policies:
      mpl_8

IP Policy mpl_5
   Administrative state: enable
   Reference count:      1
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)
           next-hop 20.1.1.1, order 100, rule 3 (reachable)
   Classifier control list: *, precedence 1000
      forward

   Referenced by interfaces:
      ATM5/0.2  output policy, statistics enabled, virtual-router default
```

```
   Referenced by profiles:
      None

   Component policies:
      p1
      p2

IP Policy mpl_8
   Administrative state: enable
   Reference count:      1
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C1, precedence 80
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)
           next-hop 20.1.1.1, order 100, rule 3 (reachable)
      color yellow
   Classifier control list: C4, precedence 900
      color red

   Referenced by interfaces:
      ATM5/0.1  input policy, statistics enabled, virtual-router default

   Referenced by profiles:
      None

   Component policies:
      p1
      p3
```

15. Detach p1 from atm 5/0.1. Merge policy mpl_8 is detached and deleted, and only p3 is attached to this interface.

```
host1(config)#interface atm 5/0.1
host1(config-subif)#no ip policy input p1
host1(config-subif)#exit
```

16. Display policies to verify that p3 is attached to atm 5/0.1 and mpl_8 is removed.

```
host1#show policy-list

                                  Policy Table
                                  ------ -----
IP Policy p1
   Administrative state: enable
   Reference count:      1
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)

   Referenced by interfaces:
      None
```

```
   Referenced by profiles:
      None

   Referenced by merge policies:
      mpl_5

IP Policy p2
   Administrative state: enable
   Reference count:      1
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 20.1.1.1, order 100, rule 3 (active)
   Classifier control list: *, precedence 1000
      forward

   Referenced by interfaces:
      None

   Referenced by profiles:
      None

   Referenced by merge policies:
      mpl_5

IP Policy p3
   Administrative state: enable
   Reference count:      1
   Classifier control list: C1, precedence 80
      color yellow
   Classifier control list: C4, precedence 900
      color red

   Referenced by interfaces:
      ATM5/0.1  input policy, statistics disabled, virtual-router default

   Referenced by profiles:
      None

   Referenced by merge policies:
      None

IP Policy mpl_5
   Administrative state: enable
   Reference count:      1
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)
           next-hop 20.1.1.1, order 100, rule 3 (reachable)
   Classifier control list: *, precedence 1000
      forward
```

```
   Referenced by interfaces:
      ATM5/0.2  output policy, statistics enabled, virtual-router default

   Referenced by profiles:
      None

   Component policies:
      p1
      p2
```

17. Detach p3 from atm 5/0.1.

```
host1(config)#interface atm 5/0.1
host1(config-subif)#no ip policy input p3
host1(config-subif)#exit
```

18. Detach p1 from atm 5/0.2. Merge policy mpl_5 is detached and deleted and only p2 is now attached.

```
host1(config)#interface atm 5/0.2
host1(config-subif)#no ip policy output p1
host1(config-subif)#exit
```

19. Detach p2 from atm 5/0.2.

```
host1(config)#interface atm 5/0.2
host1(config-subif)#no ip policy output p2
host1(config-subif)#exit
```

20. Display policies to verify that no merge policies exist and that all other policies have a 0 reference count because they are not attached anywhere.

```
host1#show policy-list

                                  Policy Table
                                  ------ -----
IP Policy p1
   Administrative state: enable
   Reference count:      0
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)

IP Policy p2
   Administrative state: enable
   Reference count:      0
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 20.1.1.1, order 100, rule 3 (active)
   Classifier control list: *, precedence 1000
      forward
```

```
IP Policy p3
   Administrative state: enable
   Reference count:      0
   Classifier control list: C1, precedence 80
      color yellow
   Classifier control list: C4, precedence 900
      color red
```

Related Topics

- Merging Policies Overview on page 87
- *Chapter 9, Monitoring Policy Management*

Parent Group Merge Algorithm

The parent group merge algorithm enables the system to merge policies that contain references to parent groups and create an internal parent group for each internal parent group in a component policy in the final merged policy. There is a one-to-one correspondence between an internal parent group in the merged policy and an internal parent group in a component policy.

NOTE: The naive parent group merging algorithm is not compatible with this parent group merge algorithm. If you have service definitions that used the naive parent group algorithm, you need to modify those service definitions to work with this algorithm.

- If there is no existing internal parent group with the same name in the merged policy, the system creates a corresponding internal parent group with the same name.
- If an internal parent group with the same name already exists, the system uses a name built by appending an internally generated sequence number to the name of the internal parent group in the component policy.
- If the length of the name exceeds the maximum length allowed, the policy merge fails.
- If a classifier group in a component policy refers to an internal parent group, the same classifier group in the merged policy corresponds to the internal parent group in the merged policy.
- If a classifier group in a component policy refers to an external parent group, the same classifier group in the merged policy refers to the same external parent group.
- If there is a conflict where two or more component policies contain the same classifier group referring to an internal parent group in a corresponding component policy or to an external parent group, then last one is used.

In the following example, component policies P1 and P2 create the merged policy mpl_88000001.

```
host1#show policy-list P1

                                  Policy Table
                                  ------ -----
IP Policy P1
   Administrative state: enable
   Reference count:      1
   Classifier control list: *, precedence 100, parent-group Z
    forward
   Classifier control list: A, precedence 100, parent-group X
forward
   Classifier control list: B, precedence 100, parent-group X
    forward
   Classifier control list: C, precedence 100, external parent-group EPG1
parameter foo
    forward
   Classifier control list: D, precedence 100, external parent-group EPG1
parameter foo
    forward

   Parent group: X, parent-group Z
      rate-limit-profile R1
   Parent group: Z
      rate-limit-profile R2

host1#show policy-list P2

                                  Policy Table
                                  ------ -----
IP Policy P2
   Administrative state: enable
   Reference count:      1
   Classifier control list: B, precedence 100, parent-group X
    forward
   Classifier control list: C, precedence 100, parent-group Y
       forward
   Classifier control list: D, precedence 100, external parent-group EPG2
parameter abcd
    forward

   Parent group: X, parent-group Y
      rate-limit-profile R3
   Parent group: Y
      rate-limit-profile R4

host1#show policy-list mpl_88000001

                                  Policy Table
                                  ------ -----

IP Policy mpl_88000001
Administrative state: enable
Reference count:      1
   Classifier control list: *, precedence 100, parent-group Z
    forward
   Classifier control list: A, precedence 100, parent-group X
    forward
   Classifier control list: B, precedence 100, parent-group X_1
    forward
```

```
   Classifier control list: C, precedence 100, parent-group Y
forward
   Classifier control list: D, precedence 100, external parent-group EPG2
parameter abcd
    forward

   Parent group: X, parent-group Z
      rate-limit-profile R1
   Parent group: Z
      rate-limit-profile R2
   Parent group: X_1, parent-group P2_Y
      rate-limit-profile R3
   Parent group: Y
      rate-limit-profile R4

   Referenced by interfaces:
      ATM5/0.1  input policy, statistics enabled, virtual-router default

   Referenced by profiles:
      None

   Component policies:
      P1
      P2
```

Overlapping Classification for IP Input Policy

IP auxiliary input policy can be used with IP input policy to provide overlapping classification. Two policies, each with a set of independent rules and actions, run in sequence so that each policy can independently produce a set of actions in sequence. A packet that matches both the input policies and auxiliary input policies is subject to both sets of policy actions.

E-series routers allow four input and two output policies per IP interface:

- One secure input policy
- Three nonsecure input policies
- One secure output policy
- One nonsecure output policy

Each classifier-group has a set of associated actions that is taken if it is the highest priority match. The system performs only one set of actions per policy attachment. By using an input and secondary-input policy, you can have overlapping classification with multiple policy actions on ingress. Overlapping classification on egress is not supported.

An additional policy attachment point enables overlapping classification within the input classification stage, between the input and secondary-input stages. There are five attachment points for IP policies that are executed in series:

- input
- secondary-input

- secure-input
- output
- secure-output

An explicit filter action, a forward action with a null next-interface, or a rate-limit action can cause an immediate packet discard at any stage. Other actions, such are marking and coloring can be done at each stage, with the last of each of these actions taking precedence over the others.

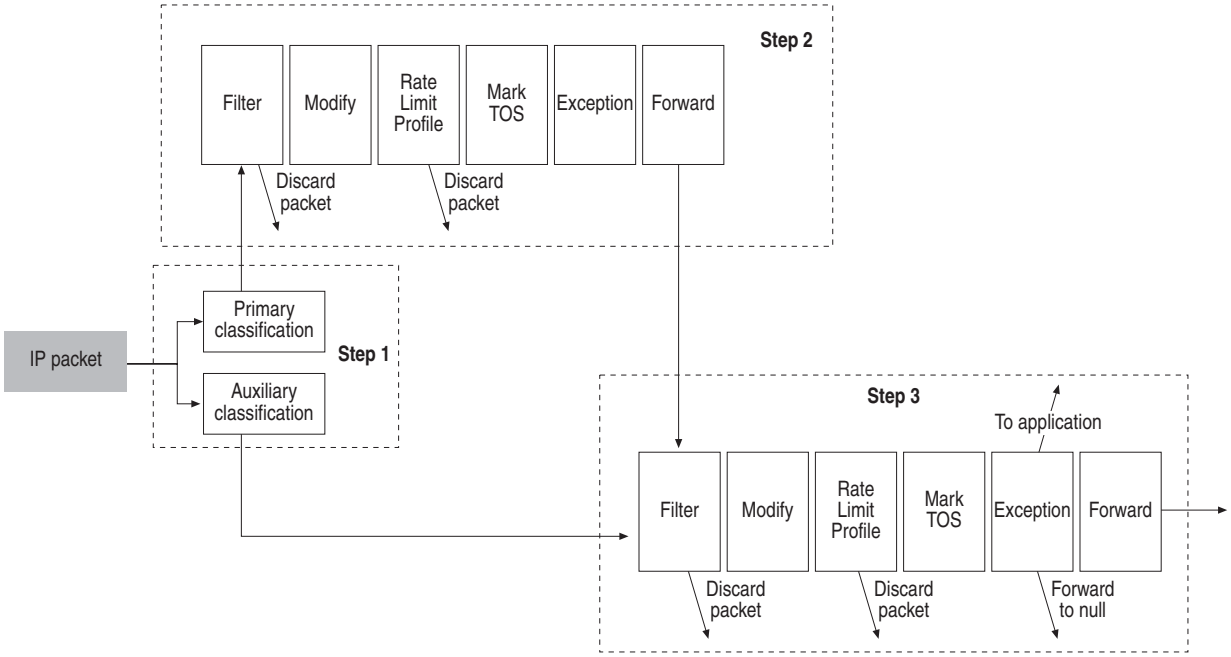
For example, unique policies can be attached at each stage, all of which mark the IP TOS field differently. The packet then exits the router with the TOS value that was set in the output policy stage. However, if TOS is also used as a classification (input) term for each of these policies, three different TOS values are presented to the classifier:

- Original TOS received
- TOS modified by the input policy
- TOS value modified by the secondary-input policy

Figure 7 shows the input policy stage after the addition of the auxiliary substage. It is divided into three steps:

1. Apply classification for both substages.
2. Perform policy actions (if any) for the primary attachment.
3. Perform policy actions (if any) for the auxiliary attachment.

Figure 7: Input Policy with Primary Stage and Auxiliary Substage



The order of policy action execution for each attachment is:

1. Filter
2. Modify (includes setting of color, traffic class, user packet class) and Log
3. Rate limit profile/color
4. Mark TOS
5. Exception
6. Forward

Starting Policy Processing

Input and auxiliary-input classification operations, specified by the details of each policy, are performed in parallel. Classifier inputs for both policies are determined concurrently using the initial values of the classification terms. Policy attachments within a stage cannot communicate between the input and auxiliary-input classification operations. For example, any changes made by the input attachment to traffic-class, color, TOS, or user packet class are not visible in the auxiliary-input policy classification. If this communication is needed, it can only be done between different policy stages, rather than within a single stage.

The results of the input policy actions are passed forward to the auxiliary-input policy action processing. This means that a color-aware rate limit profile action in the auxiliary substage recognizes any change in color caused by primary policy actions.

Processing the Classifier Result

The classifier result of the input policy attachment is processed and a set of actions is identified. When you configure filter, it is the first action taken and immediately discards the packet. This is followed by any modification, such as mark or logging. If a rate limit profile is configured, the packet is dropped or colored. If the packet is not dropped, it is sent to the exception path (if configured). If the packet is not exceptioned, any configured forward action is saved in the packet for use later (unless overridden in Step 3). (See Figure 7 on page 111.)

Some information generated by the action processing in Step 2 is forwarded to Step 3, where it may affect the action processing for the auxiliary-input attachment. This information can include color, exception information, and forwarding information. The color can affect a rate-limit in the auxiliary-input attachment. Step 3 acts on the exception and forwarding information, if it is not overridden by similar actions from the auxiliary-input attachment.

The transmit information (transmit conditional, transmit unconditional, transmit final) generated with hierarchical policies does not carry forward from input to auxiliary-input action processing.

Processing the Auxiliary-Input Policy Attachment

If the packet is not filtered or exceptioned in policy Step 2, the classifier result of the auxiliary policy attachment is processed and a set of actions identified. The packet can be filtered or exceptioned at this time. These operations, if configured, are performed regardless of whether a forward action was performed in Step 2. If the packet is not discarded, either by a filter action or a rate limit, it can be exceptioned (if configured). If the packet is not filtered, rate-limited, or exceptioned, any configured forward action is applied and overrides any forward action from Step 2. If no forward action is configured, any forward action from Step 2 applies.

Policy Actions

The set of actions in the following list specified by the input and auxiliary-input policy attachments are executed in the order: input, auxiliary-input.

- Color packet action—Explicitly sets the packet color. Each policy attachment can set the color and the final value persists. A rate limit profile action can also set the color, which overrides the value of the color packet action.
- Mark action—Each attachment can set the TIP TOS, TOS precedence, and DS fields. The cumulative result of all configured mark actions determines the resulting value of these fields.
- Mirror action—Executes in the order: secure input policy follows secondary input policy, secure output policy follows output policy. Mirror is the only supported action for secure policies.

- Rate-limit profile action—Can be specified by any nonsecure input policy attachment. This enables the application of multiple rate limits either within a policy stage or across policy stages. These rate limits run serially; if the rate limit imposed in the primary substage causes the packet to drop, the auxiliary rate limit does not run and the associated token buckets are not affected. If you configure more than a single rate limit per interface, it significantly impacts forwarding performance. Attaching two policies with rate limit profiles in the same policy stage is equivalent to having two policies attached in the same order, but in separate stages.

- Traffic class action—If both the input and auxiliary-input attachments need this action, the value configured in the auxiliary policy overwrites that of the primary policy.

- User packet class action—Can be set twice per stage, with the second value overriding the first.

- The filter, next-hop, forward interface, and forward next-hop actions—Mutually exclusive within a classifier group. However, two policies in series can result in conflicting actions, which are resolved using the following precedence rules:

  - The filter action has highest priority. A filter action in input or auxiliary-input policy always prevails.

  - The exception action takes precedence over forward actions.

  - If multiple exception actions are required by the policy attachments, the last one takes precedence.

  - If forward operations are required by both input and auxiliary-input policy attachments, the auxiliary-input forward action takes precedence.

In Table 11, the filter action for the input policy takes precedence over the others so that if a filter action is configured for either policy, the packet is filtered. If neither policy has a filter action, but both policies specify a forward action, the action specified by the auxiliary policy takes precedence. If only one policy specifies a forwarding action, that action is executed. The next-hop rule is inoperative for auxiliary-input policies, just as it is for secondary input policies. This policy rule has been superseded (but not replaced) by the forward next-hop rule, which is operative for auxiliary-input policies.

Table 11: Filter, Forward, and Exception Action Resolution for Input and Auxiliary-Input Policies

Input Action	Secondary Input Action					
	None	Exception	Filter	Next-hop	Forward Interface	Forward Next-hop
None	None	Exception Auxiliary	Filter	None	Forward Interface Auxiliary	Forward Next-hop Auxiliary
Exception	Exception Primary	Exception Auxiliary	Filter	Exception	Exception Primary	Exception Primary
Filter	Filter	Filter	Filter	Filter	Filter	Filter
Next-hop	Next-hop Primary	Exception Auxiliary	Filter	Next-hop Primary	Forward Interface Auxiliary	Forward Next-hop Auxiliary
Fwd Interface	Forward Interface Primary	Exception Auxiliary	Filter	Forward Interface Primary	Forward Interface Auxiliary	Forward Next-hop Auxiliary
Fwd next-hop	Forward Next-hop Primary	Exception Auxiliary	Filter	Forward Next-hop Primary	Forward Interface Auxiliary	Forward Next-hop Auxiliary

Chapter 7

Creating Hierarchical Policies for Interface Groups

This chapter provides information for configuring policy-based routing management on E-series routers.

This chapter discusses the following topics:

Hierarchical Policies for Interface Groups Overview

Hierarchical policies allow classifier groups and parent groups within a policy to point to line module global parent groups. The line module global parent groups (external parent groups) can point to other external parent groups. Full intra-interface policy hierarchies for all forwarding layer policies allow classified flows within a policy attachment to share bandwidth. Bandwidth-sharing between interfaces uses line module global parent group definitions and interface grouping. However, if you need to share bandwidth between two or more interfaces, rate-limits must be chained beyond a single attachment.

Policies for interface groups include external parent groups that are implicitly instantiated during policy attachment based on each unique interface group encountered.

External Parent Groups

Parent groups act as nonleaf nodes in a hierarchical policy. You can build a hierarchy of policers using classifier groups as leaf nodes and parent groups as parent nodes within a policy list. Each classifier group (with or without a rate limit) can point to a single parent group and that parent group can point to another parent group. To avoid undefined hierarchies, each node can only point to one other node.

The inter-interface hierarchical model includes references to parent groups that are defined externally from a policy list. This enables you to define hierarchical nodes outside the scope of a policy-list attachment. In Global Configuration mode, each external parent group can have a rate-limit profile defined and have a reference to another external parent group.

The classifier groups and parent groups within a policy list can point to external parent groups for all policies that implement hierarchical policies. Each external parent group reference must also have a policy parameter name.

External parent group names are global. Internal parent group names are local to each policy configuration. Because both of these name spaces are different, you can configure overlapping names.

Configuring Hierarchical Policy Parameters

You configure policy parameters in Global Configuration mode. Only hierarchical policy parameters can have external parent group references. Each parameter has a single value, depending on the type of parameter. The hierarchical policy parameter can have a single numeric value or a keyword.

In Interface Configuration mode, you can override the value for a policy parameter for each interface. The value for a parameter configured in Interface Configuration mode supersedes the value configured for the parameter in Global Configuration mode. However, if a parameter is not configured in Interface Configuration mode, the value configured in Global Configuration mode is used.

Each reference to a policy parameter in a policy is substituted with its value for all attachments of this policy at the interface. The value can come from the interface or global configuration for the parameter. Therefore, the value configured for the parameters referenced in policies can be different for attachments at different interfaces. This enables you to have an attachment-specific configuration in a policy list that is deferred until the policy is attached.

There are two types of values that a hierarchical policy parameter can take: numeric and keyword. Keywords are resolved to numeric values during configuration of a policy parameter at the interface.

The following example assigns a value of 10 to policy parameter A in Global Configuration mode.

```
host1(config)#policy-parameter A hierarchical
host1(config-policy-parameter)#aggregation-node 10
host1(config-policy-parameter)#exit
```

The following example assigns value 1 to policy parameter A and value 2 to policy parameter B in Interface Configuration mode. Also, the value configured for parameter A in interface fast3/0.1 overrides the value configured in the previous example.

```
host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#ip policy-parameter hierarchical A 1
host1(config-interface)#ip policy-parameter hierarchical B 2
host1(config-interface)#exit
```

The following example assigns keyword **vlan** to parameter C in Global Configuration mode.

```
host1(config)#policy-parameter C hierarchical
host1(config-policy-parameter)#aggregation-node vlan
host1(config-policy-parameter)#exit
```

The following example assigns keyword **atm-vc** to parameter C in Interface Configuration mode. Policy parameter C is assigned with interface type atm-vc for IP interface at atm3/0.1. The keyword **atm-vc** is resolved to the identifier of the ATM minor interface on which the IP interface atm3/0.1 is stacked.

```
host1(config)#interface atm 3/0.1
host1(config-interface)#ip policy-parameter hierarchical C atm-vc
host1(config-interface)#exit
```

The following keywords are supported: **atm-vc**, **atm-vp**, **atm**, **ethernet**, **vlan**, **svlan**, **fr-vc**, and **forwarding**. Table 12 indicates the mapping of shorthand notation to actual value that are used internally.

Table 12: Shorthand Notation Mapping

Shorthand number	Shorthand	Value	Supported in
1	ATM-VP *vpi*	Identifier constructed from slot, adapter, port, ATM VP id.	IP, IPv6, L2TP, and MPLS policies
2	ATM-VC	Unique identifier of the ATM minor interface	IP, IPv6, and MPLS policies
3	Ethernet	Unique identifier of Ethernet major interface	IP, IPv6, and MPLS policies
4	VLAN	Unique identifier of VLAN interface	IP, IPv6, and MPLS policies
5	SVLAN *id*	Identifier constructed from slot, adapter, port, SVLAN ID.	IP, IPv6, L2TP, and MPLS policies
6	FR-VC	Unique identifier of frame relay minor interface	IP, IPv6, and MPLS policies
7	ATM	Unique identifier of ATM major interface	IP, IPv6, and MPLS policies
8	Forwarding	Unique identifier of the forwarding interface where the parameter is configured.	IP, IPv6, L2TP, and MPLS policies

Hierarchical Aggregation Nodes

An internal parent group configured within a policy defines a hierarchical aggregation node template. An attachment of this policy creates an aggregation node for each internal parent group in a policy. Aggregation nodes are scoped within a single attachment and cannot be shared beyond a single attachment. An aggregation node stores a single rate-limit instance and statistics for this rate-limit. Aggregate nodes can be shared between two or more classified flows within a single attachment using the classifier group and parent group association.

Rate-limit aggregation nodes extend beyond a single attachment so classified flows across two or more attachments can reference the same aggregation node to share a single rate-limit instance. You can use external parent groups and policy parameters for sharing aggregate nodes across policy attachments. Each external parent group reference in a policy is accompanied by a parameter that is resolved during the attachment of the policy to an interface. An external rate-limit aggregation node can be defined by the 4-tuple (slot, direction, external parent group name, parameter value). The slot is the logical number of the line module location and the direction can be ingress or egress at the line module.

When you use hierarchical aggregation nodes, be aware of the following:

- VR/VRF—The hierarchical aggregate nodes based on external parent groups are not virtual router sensitive. The configuration allows interfaces from different virtual routers to have the same parameter name to value mapping, in which case both interfaces could share the same aggregate node created by an external parent group.

- Direction of Traffic—Hierarchical aggregate nodes are direction sensitive. The configuration does not allow input and output traffic at an interface to share the same rate-limit instance. Even when the input and output policy attachments refer to the same external parent group and parameter value, two separate aggregate nodes are created for each direction.

- Line Module—You should use hierarchical aggregate nodes. Rate limits cannot be shared across different line modules or service modules. Even when you configure the same parameter name to the same value for an external parent group, different rate-limit instances are instantiated if the interfaces are on different line modules.

RADIUS and Profile Configuration for Hierarchical Policies

You can use profiles to configure policy parameters. There is currently no RADIUS VSA support for policy parameters. Each reference to an external parent group and the chain of references from that group to other parent groups in a series requires one parent group resource for each reference and each attachment of the policy containing these references.

The rule that applies to external parent group resource count is: one resource per (interface, policy attachment type, policy name, external parent group name, parameter name) tuple; interface is the interface where the policy is attached and policy attachment type is the type of policy attachment.

A rate-limit instance for the external parent groups is created for each hierarchical aggregation node, which is a combination of (slot, direction, parent group name, parameter value) tuple; where slot is the slot number, direction is ingress or egress. A rate-limit resource will be consumed for each instance created.

If at least one policy attachment that uses an external parent group reference has statistics enabled, then statistics for the rate-limit configured within the external parent group is enabled. Each hierarchical aggregation node requires five statistics resources.

Applying a Profile to Interfaces with Service Manager

Applying a profile to the interface where the subscriber sends and receives traffic activates service for a subscriber. Similarly, to deactivate a service, you reapply the respective profile with a *negate* flag.

You can use a profile to apply the policy parameters configuration for an interface. When you apply a profile containing relevant policy parameter commands to an interface, the parameter configuration is uniquely maintained for each dynamic interface created using this profile. The policy parameters are not deactivated when the corresponding service containing them is deactivated and can only be modified or created by service activations.

If you write service manager macros, you should define the rate-limit hierarchy when you create the policies and profiles associated with the services to be deployed.

Hierarchical Policy Configuration Considerations

When you configure hierarchical policies for interface groups, be aware of the following considerations:

- Loops—The system performs basic checks to prevent formation of loops when external parent groups refer to other external parent groups. Also, you cannot chain together more than four rate-limits in a hierarchy.
- Asynchronous Policy Parameter Configuration—You can individually configure the policy parameter configuration in an interface and the policy attachments. If a policy parameter is not configured in the interface before a policy is attached, the value configured in Global Configuration mode for this parameter is used. You can later change the parameter value for the interface.
- Asynchronous Parent Group Rate Limit Configuration—You can configure an external parent group without a rate-limit-profile reference. In this case, the system doe not invoke a rate-limit for the external parent group (even if other nodes point to it) and calls the next node in the hierarchy.
- Parent Group Reference—The configuration fails if you do not first create an external parent group before it is referenced elsewhere.

Hierarchical Policy Quick Configuration

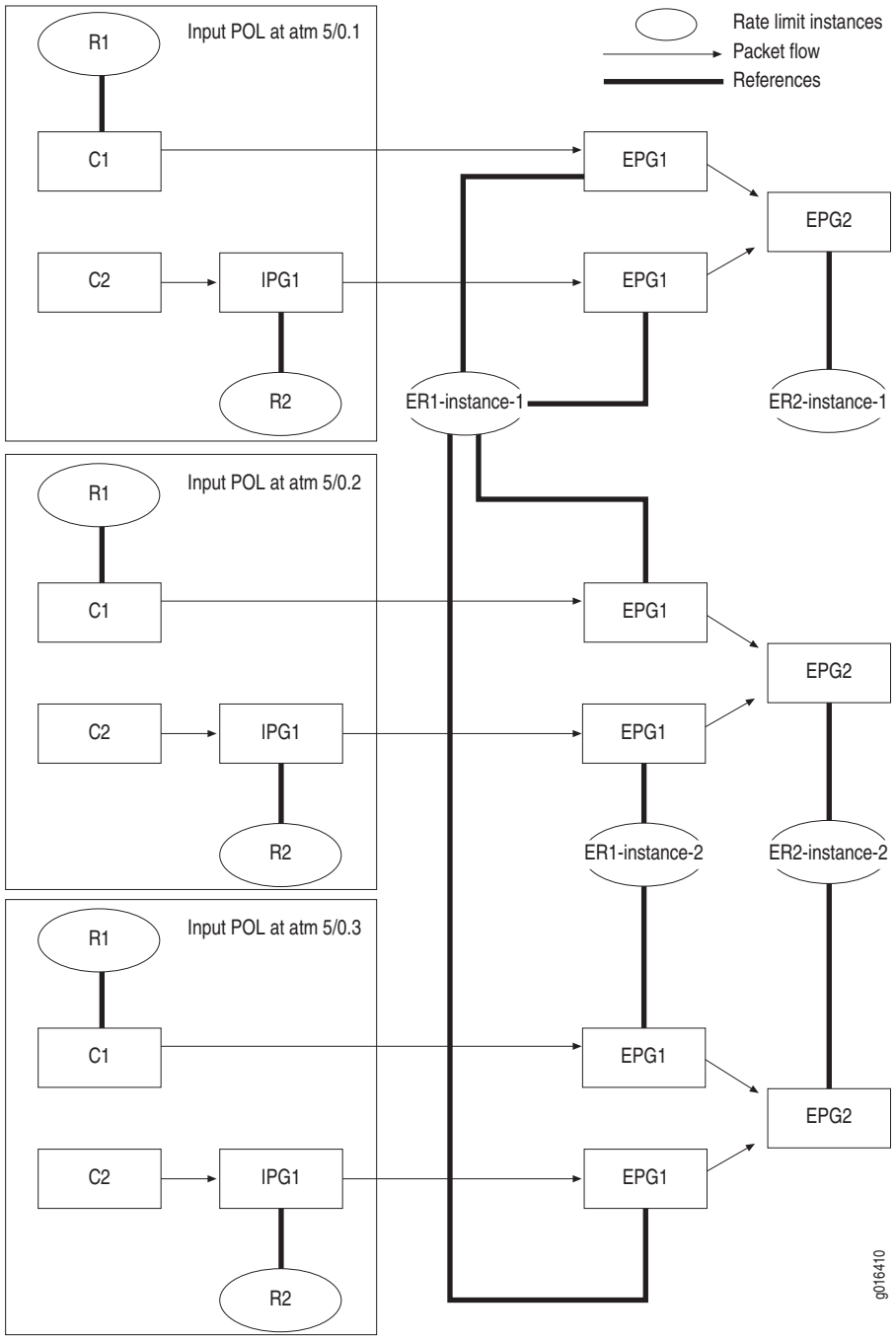
To configure hierarchical policies for interface groups, use the following steps:

1. In Global Configuration mode, create rate limit profiles of the type hierarchical.
2. In Global Configuration mode, create policy parameters of the type hierarchical.
3. In Global Configuration mode, create external parent groups.
4. In Global Configuration mode, create a policy list and use the external parent groups and policy parameters to create a hierarchy of rate limits.
5. In Interface Configuration mode, attach the policy list to the interface.
6. (Optional) In Interface Configuration mode, specify values for the hierarchical policy parameters used by the policy list.

Configuring Hierarchical Policies

The configuration in Figure 8 requires four parent group resources for each atm5/0.1, atm5/0.2, and atm5/0.3 attachment. The rate-limit instance R1 is referenced by C1 and packet flows from C1 to EPG1 to EPG2.

Figure 8: Step-by-Step Configuration



This procedure uses the following designations:

- EPG1 and EPG2 are external parent groups.
- IP1 and IP2 are internal parent groups.
- ER1, ER2, R1, and R2 are rate-limit profiles.

- POL is the name of the IP policy.
- C1 and C2 are classified flows.
- A, B, and C are policy parameters.

1. Configure two external parent groups EPG1 and EPG2. Create policy-parameter C and two external parent groups: EPG1 and EPG2.

   host1(config)#**policy-parameter C hierarchical**
   host1(config-policy-parameter)#**exit**

   host1(config)#**parent-group EPG2**
   host1(config-parent-group)#**rate-limit-profile ER2**
   host1(config-parent-group)#**exit**

   host1(config)#**parent-group EPG1**
   host1(config-parent-group)#**next-parent EPG2 parameter C**
   host1(config-parent-group)#**rate-limit-profile ER1**
   host1(config-parent-group)#**exit**

   EPG1 contains a rate-limit profile ER1 and points to EPG2 as the next parent group in series. The EPG2 reference is associated with policy parameter C. When you later use the **policy-parameter** command in Interface Configuration mode, actual values are substituted for the names. EPG2 contains a reference to rate-limit-profile ER2.

2. Configure IP policy list POL.

   host1(config)#**ip policy-list POL**
   host1(config-policy-list)#**classifier-group C1 external parent-group EPG1 parameter A**
   host1(config-policy-list-classifier-group)#**rate-limit-profile R1**
   host1(config-policy-list-classifier-group)#**exit**

   host1(config-policy-list)#**classifier-group C2 parent-group IPG1**
   host1(config-policy-list-classifier-group)#**forward**
   host1(config-policy-list-classifier-group)#**exit**

   host1(config-policy-list)#**parent-group IPG1 external parent-group EPG1 parameter B**
   host1(config-parent-group)#**rate-limit-profile R2**
   host1(config-policy-list-parent-group)#**exit**

   A classified flow C1 references EPG1 as the next parent group to call in the hierarchy. This is an external parent group that is associated with policy parameter A. The C2 classified flow points to internal parent group IPG1, which contains rate-limit-profile R2 and points to EPG1 as the next parent group to call in the hierarchy. The EPG1 reference is associated with policy parameter B. When you later use the **policy-parameter** command in Interface Configuration mode, the policy parameters are given numeric values.

3. Attach POL to atm5/0.1 as an input policy.

```
host1(config)#interface atm 5/0.1
host1(config-interface)#ip policy-parameter hierarchical A 1
host1(config-interface)#ip policy-parameter hierarchical B 1
host1(config-interface)#ip policy-parameter hierarchical C 1
host1(config-interface)#ip policy input POL statistics enabled
host1(config-interface)#exit
```

Policy list POL contains three parameter names that must be substituted with actual values. This attachment contains two internal rate-limit instances, one for R1 and one for R2. This attachment also contains one parent group instance for IPG1, one parent-group instance for (EPG1, parameter A) tuple, one for (EPG1, parameter B) tuple, and one for (EPG2, parameter C) tuple. Value number 1 is substituted for parameters A, B, and C when you use the **policy-parameter** command. Because of this policy attachment and the **policy-parameter** command, the following aggregation nodes are created: (slot 5, ingress, EPG1, 1), (slot 5, ingress, EPG2, 1). The system creates a rate-limit instance for each aggregation node: ER1-instance-1 and ER2-instance-1, respectively. ER1-instance-1 is referenced in parent-group instances (EPG1, parameter A) and (EPG1, parameter B). ER2-instance-1 is referenced in the parent group instance (EPG2, parameter C).

4. Attach POL to atm5/0.2 as input policy.

```
host1(config)#interface atm 5/0.2
host1(config-interface)#ip policy-parameter hierarchical A 1
host1(config-interface)#ip policy-parameter hierarchical B 2
host1(config-interface)#ip policy-parameter hierarchical C 2
host1(config-interface)#ip policy input POL statistics enabled
host1(config-interface)#exit
```

Policy list POL contains three parameter names that must be substituted with actual values. This attachment consumes two internal rate-limit instances: one for R1 and one for R2. This attachment also consumes one parent group instance for IPG1, one parent-group instance for (EPG1, parameter A) tuple, one for (EPG1, parameter B) tuple, and one for (EPG2, parameter C) tuple as in Step 3. When you use the **policy-parameter** command, parameter A is substituted with value 1 and parameters B and C are substituted with value 2. Because of this policy attachment and the policy-parameter commands, the following aggregation nodes are identified: (slot 5, ingress, EPG1, 1), (slot 5, ingress, EPG1, 2), (slot 5, ingress, EPG2, 2). The (slot 5, ingress, EPG1, 1) node was already created in Step 3 and was named ER1-instance-1. The other two aggregation nodes are now created and named ER1-instance-2 and ER2-instance-2, respectively. ER1-instance-1 is referenced by parent-group instance (EPG1, parameter A), ER1-instance-2 is referenced by parent group instance (EPG1, parameter B), and ER2-instance-2 is referenced by the parent group instance (EPG2, parameter C).

5. Attach POL to atm5/0.3 as input policy.

```
host1(config)#interface atm 5/0.3
host1(config-interface)#ip policy-parameter hierarchical A 2
host1(config-interface)#ip policy-parameter hierarchical B 1
host1(config-interface)#ip policy-parameter hierarchical C 2
host1(config-interface)#ip policy input POL statistics enabled
host1(config-interface)#exit
```

Policy list POL contains three parameter names that need to be substituted with actual values. This attachment consumes two internal rate-limit instances: one for R1 and one for R2. This attachment also consumes one parent group instance for IPG1, one parent-group instance for (EPG1, parameter A) tuple, one for (EPG1, parameter B) tuple, and one for (EPG2, parameter C) tuple. When you use the **policy-parameter** command, parameters A and C are substituted with value 2 and parameter B is substituted with value 1. Because of this policy attachment and use of the **policy-parameter** commands, the following aggregation nodes are identified; (slot 5, ingress, EPG1, 2), (slot 5, ingress, EPG1, 1), (slot 5, ingress, EPG2, 2). All three aggregation nodes were created in earlier steps and were named ER1-instance-2, ER1-instance-1, and ER2-instance-2, respectively. ER1-instance-2 is referenced by parent-group instances (EPG1, parameter A), ER1-instance-1 is referenced by parent group instance (EPG1, parameter B), and ER2-instance-2 is referenced by the parent group instance (EPG2, parameter C).

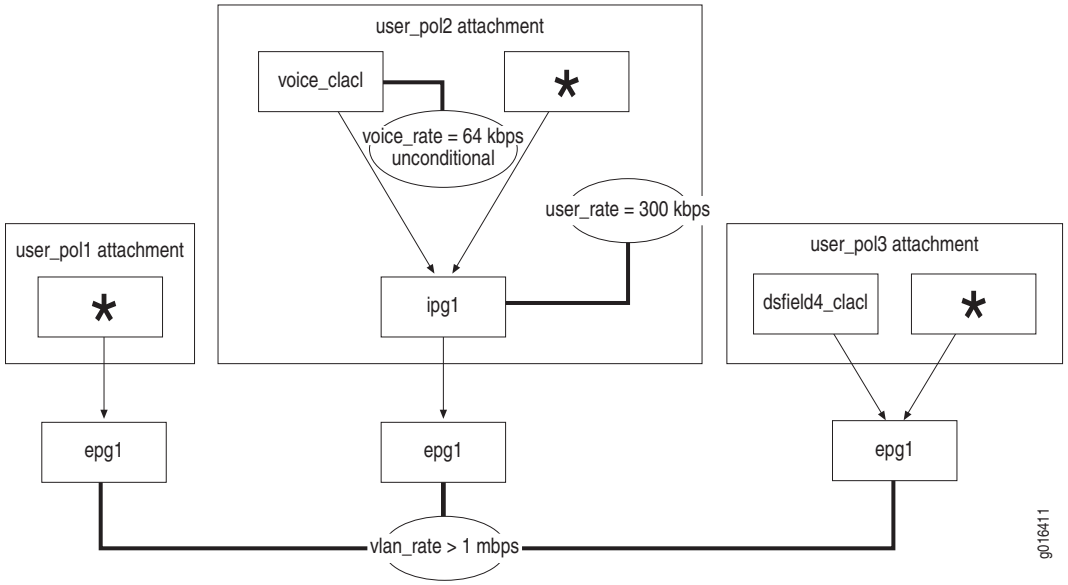
VLAN Rate Limit Hierarchical Policy for Interface Groups Configuration Example

In this example, three users from a small business office are connected to an E-series router through the same VLAN interface. The contracted maximum for the business is 1 Mbps in the upstream direction. The downstream direction is served through QoS profiles and therefore is not shown here.

Figure 9 shows the following:

- User user_pol1 is attached to the first user's IP interface and does not have a rate limit.
- User user_pol2 is attached the second user's interface and has an individual rate limit of 300Kbps and preferred voice traffic at 64Kbps.
- User user_pol3 is attached to the third user's interface and has some traffic marked with a low delay (Dsfield = 4), but there are no rate limitations applied.
- Policer instance VLAN_RATE is shared across all three instances of EPG1 and limits the total upstream traffic from three users to 1 Mbps.

Figure 9: VLAN Rate-Limit Configuration



1. Create a rate limit to enforce the contracted maximum for the small business. Create an external parent group to hold this rate limit.

   host1(config)#**rate-limit-profile VLAN_RATE two-rate hierarchical**
   host1(config-rate-limit-profile)#**committed-rate 1000000**
   host1(config-rate-limit-profile)#**committed-action transmit final**
   host1(config-rate-limit-profile)#**exit**

   host1(config)#**parent-group EPG1**
   host1(config-parent-group)#**rate-limit-profile VLAN_RATE**
   host1(config-parent-group)#**exit**

   Verify the parent group configuration.

```
host1#show parent-group EPG1

                                Parent Group Table
                                ------ ----- ------
Parent Group EPG1
   Reference count: 0
   Rate limit profile: VLAN_RATE
```

2. Create a policy list to attach to user 1.

   host1(config)#**policy-parameter A hierarchical**
   host1(config-policy-parameter)#**exit**

   host1(config)#**ip policy-list USER_POL1**
   host1(config-policy-list)#**classifier-group * external parent-group EPG1 parameter A**
   host1(config-policy-list-classifier-group)#**forward**
   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**exit**

Verify the policy list configuration.

```
host1#show policy-list USER_POL1

                                  Policy Table
                                  ------ -----
IP Policy USER_POL1
   Administrative state: enable
   Reference count:      0
   Classifier control list: *, precedence 100, external parent-group EPG1
parameter A
      forward
```

3. Create a policy list to attach to user 2. Also, create a rate limit to police voice traffic and another rate limit to police all traffic for user 2. Because voice traffic is preferred, it borrows the tokens unconditionally from all aggregate policers in the hierarchy.

```
host1(config)#rate-limit-profile VOICE_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 64000
host1(config-rate-limit-profile)#committed-action transmit unconditional
host1(config-rate-limit-profile)#exit

host1(config)#rate-limit-profile USER_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 300000
host1(config-rate-limit-profile)#committed-action transmit conditional
host1(config-rate-limit-profile)#exit

host1(config)#ip classifier-list VOICE_CLACL udp any any eq 10000

host1(config)#ip policy-list USER_POL2
host1(config-policy-list)#classifier-group VOICE_CLACL parent-group IPG1
host1(config-policy-list-classifier-group)#rate-limit-profile VOICE_RATE
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group * parent-group IPG1
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#parent-group IPG1 external parent-group EPG1
parameter A
host1(config-policy-list-parent-group)#rate-limit-profile USER_RATE
host1(config-policy-list-parent-group)#exit
host1(config-policy-list)#exit
```

Verify the policy list configuration.

```
host1#show policy-list USER_POL1

                                  Policy Table
                                  ------ -----
IP Policy USER_POL2
   Administrative state: enable
   Reference count:      0
   Classifier control list: VOICE_CLACL, precedence 100, parent-group IPG1
      rate-limit-profile VOICE_RATE
   Classifier control list: *, precedence 100, parent-group IPG1
      forward
   Parent group: IPG1, external parent-group EPG1 parameter A
      rate-limit-profile USER_RATE
```

4. Create a policy list to attach to user 3 and mark Dsfield = 4 traffic with a special traffic class.

```
host1(config)#ip classifier-list DSFIELD4_CLACL ip any any dsfield 4
host1(config)#ip policy-list USER_POL3
host1(config-policy-list)#classifier-group DSFIELD4_CLACL external parent-group
EPG1 parameter A
host1(config-policy-list-classifier-group)#traffic-class LOW_DROP
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group * external parent-group EPG1
parameter A
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
```

   The policies created earlier are attached statically to the user's corresponding entry interface in the E-series router. In this case, fast3/0.1 connects to user 1, fast3/0.2 connects to user 2, and fast3/0.3 connects to user 3.

5. Create the major interface.

```
host1(config)#interface fastEthernet 3/0
host1(config-interface)#encapsulation vlan
host1(config-interface)#exit
```

6. Create an interface for user 1, attach USER_POL1, and map parameter A to the VLAN interface stacked below the shared IP interface.

```
host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#exit

host1(config)#interface ip 3/0.1.1
host1(config-interface)#ip policy-parameter hierarchical A vlan
host1(config-interface)#ip policy input USER_POL1 statistics enabled
host1(config-interface)#exit
```

7. Create the interface for user 2, attach USER_POL2, and map parameter A to the VLAN interface.

```
host1(config)#interface ip 3/0.1.2
host1(config-interface)#ip policy-parameter hierarchical A vlan
host1(config-interface)#ip policy input USER_POL2 statistics enabled
host1(config-interface)#exit
```

8. Create the interface for user 3, attach USER_POL3, and map parameter A to the VLAN interface.

```
host1(config)#interface ip 3/0.1.3
host1(config-interface)#ip policy-parameter hierarchical A vlan
host1(config-interface)#ip policy input USER_POL3 statistics enabled
host1(config-interface)#exit
```

9. For dynamic users, under each user's record in RADIUS, you can specify the ingress policy name. However, you can only specify the policy parameter through the profile.

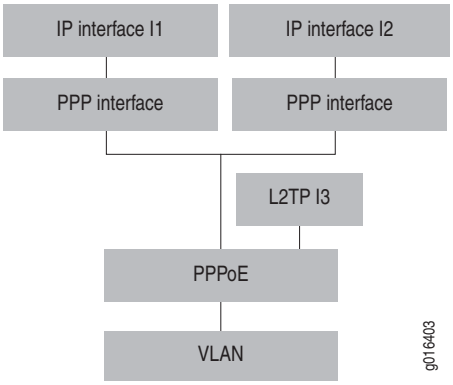
```
host1(config)#profile PPPOE_PROF1
host1(config-profile)#ip policy-parameter hierarchical A vlan
host1(config-profile)#exit

host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#encapsulation pppoe
host1(config-interface)#profile PPPOE_PROF1
host1(config-interface)#pppoe auto-configure
host1(config-interface)#exit
```

Wholesale L2TP Model Hierarchical Policy Configuration Example

In this example:

- There are two terminated subscribers and their corresponding IP interfaces are I1 & I2 in the ERX.
- There is a single tunneled subscriber whose interface is I3.
- Interfaces I1 and I2 have dedicated 1 Mbps bandwidth each and interface I3 has dedicated 10 Mbps bandwidth. However, if interface I3 is not forwarding any traffic, then the allocated 10 Mbps can be shared by interfaces I1 and I2. Therefore, interfaces I1 and I2 can individually go up to a maximum of 11 Mbps if only one is actively sending traffic. If both interfaces are actively sending traffic, they can both get a maximum of 6 Mbps. However, any time interface I3 is actively sending traffic, it can forward up to the contracted 10 Mbps and interfaces I1 and I2 fall back to 1 Mbps.

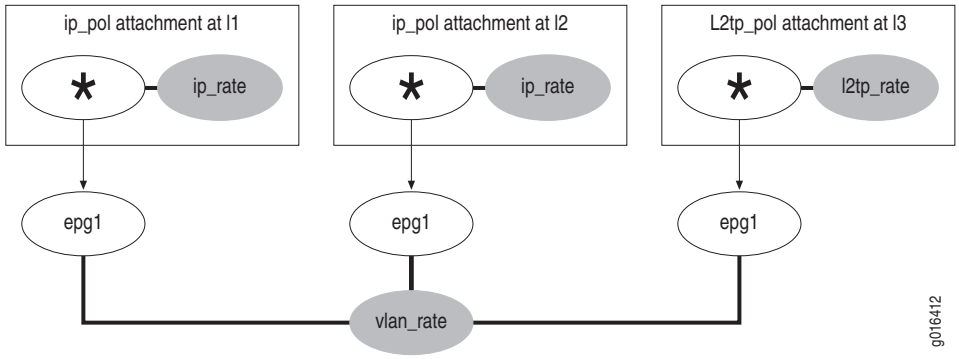
Figure 10: Interface Stack for Wholesale L2TP Mode



To use this example, you must configure the following:

- At interfaces I1 and I2:
  - IP_RATE, Committed Rate:1 Mbps
  - Peak Rate: 11 Mbps
  - Committed Action: transmit unconditional
  - Conformed Action: transmit conditional
  - Exceeded Action: drop
- At I3—L2TP_RATE:
  - Committed Rate: 10 Mbps
  - Peak Rate: 0 Mbps
  - Committed Action: transmit unconditional
  - Conformed Action: drop
  - Exceeded Action: drop
- Policers at I1, I2, and I3 feed into a single policer that has the following configuration:
  - VLAN_RATE, Committed Rate: 12 Mbps
  - Peak Rate: 0 Mbps
  - Committed Action: transmit final
  - Conformed Action: drop
  - Exceeded Action: drop
- IP policy USER_POL1 is attached as input to I1, IP policy USER_POL2 is attached as input to I2, and L2TP policy USER_POL3 is attached as input to I3.
- Policer instance VLAN_RATE is shared across all three instances of EPG1.

Figure 11: Wholesale L2TP Configuration



1. Create a rate-limit that can be shared across all forwarding interfaces. Create an external parent group to hold this rate limit.

   host1(config)#**rate-limit-profile VLAN_RATE two-rate hierarchical**
   host1(config-rate-limit-profile)#**committed-rate 12000000**
   host1(config-rate-limit-profile)#**committed-action transmit final**
   host1(config-rate-limit-profile)#**exit**

   host1(config)#**parent-group EPG1**
   host1(config-parent-group)#**rate-limit-profile VLAN_RATE**
   host1(config-parent-group)#**exit**

2. Create a policy list to attach to users 1 and 2.

   host1(config)#**rate-limit-profile IP_RATE two-rate hierarchical**
   host1(config-rate-limit-profile)#**committed-rate 1000000**
   host1(config-rate-limit-profile)#**committed-action transmit unconditional**
   host1(config-rate-limit-profile)#**peak-rate 11000000**
   host1(config-rate-limit-profile)#**conformed-action transmit conditional**
   host1(config-rate-limit-profile)#**exit**

   host1(config)#**policy-parameter A hierarchical**
   host1(config-policy-parameter)#**exit**
   host1(config)#**ip policy-list IP_POL**
   host1(config-policy-list)#**classifier-group * external parent-group EPG1 parameter A**
   host1(config-policy-list-classifier-group)#**rate-limit-profile IP_RATE**
   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**exit**

3. Create a policy list to attach to user 3.

   host1(config)#**rate-limit-profile L2TP_RATE two-rate hierarchical**
   host1(config-rate-limit-profile)#**committed-rate 10000000**
   host1(config-rate-limit-profile)#**committed-action transmit unconditional**
   host1(config-rate-limit-profile)#**exit**

```
host1(config)#l2tp policy-list L2TP_POL
host1(config-policy-list)#classifier-group * external parent-group EPG1
parameter A
host1(config-policy-list-classifier-group)#rate-limit-profile L2TP_RATE
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
```

4. In both terminated users' record in RADIUS, you must specify the ingress policy name IP_POL. You must specify the ingress policy name L2TP_POL in the tunneled user's record in RADIUS. However, be sure to specify the policy parameter through a profile.

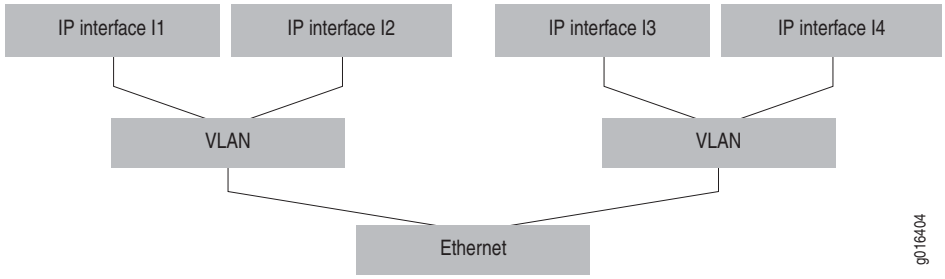
```
host1(config)#profile PPPOE_PROF1
host1(config-profile)#ip policy-parameter hierarchical A 1
host1(config-profile)#l2tp policy-parameter hierarchical A 1
host1(config-profile)#exit

host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#encapsulation pppoe
host1(config-interface)#profile PPPOE_PROF1
host1(config-interface)#pppoe auto-configure
host1(config-interface)#exit
```

Aggregate Rate Limit for All Nonvoice Traffic Hierarchical Policy Configuration Example

In this example:

- There are four IP sessions and their corresponding interfaces are I1, I2, I3, and I4.
- Each interface corresponds to a dynamic user.
- All users can send a maximum of 1 Mbps video traffic each, but the total bandwidth for all video traffic combined is 1.5 Mbps for a specific VLAN.
- Similarly, all users can send a maximum of 5 Mbps data traffic, but the sum of all data traffic on an Ethernet port is 10 Mbps. Interfaces I1-I4 are interfaces where you can attach policies.

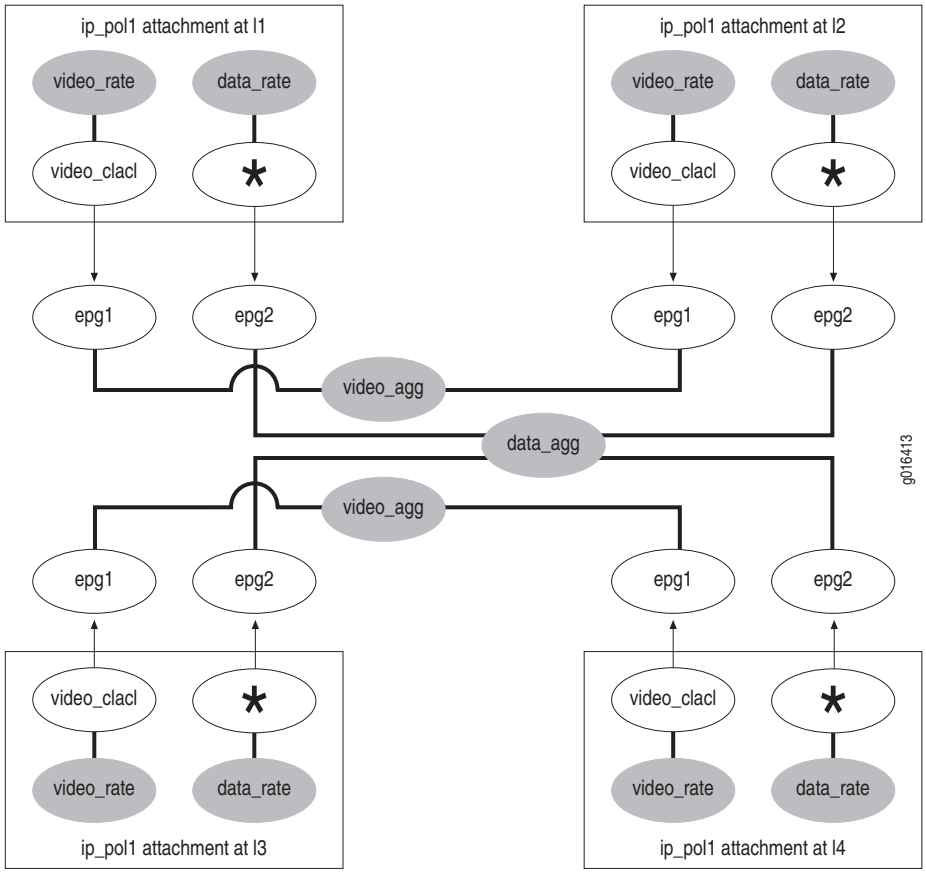
Figure 12: Interface Stack for Aggregate Rate Limit



This example uses the following:

- At I1, I2, I3, I4:
  - Classified Video Flow. VIDEO_RATE, Committed Rate: 1 Mbps
  - Peak Rate: 0 Mbps
  - Committed Action: transmit conditional
  - Conformed Action: drop
  - Exceeded Action: drop
- At I1, I2, I3, I4:
  - Classified Data Flow. DATA_RATE, Committed Rate: 5 Mbps
  - Peak Rate: 0 Mbps
  - Committed Action: transmit conditional
  - Conformed Action: drop
  - Exceeded Action: drop
- All classified video flow policers over each VLAN interface feed into a single policer with the following configuration:
  - VIDEO_AGG, Committed Rate: 1.5 Mbps
  - Peak Rate: 0 Mbps
  - Committed Action: transmit final
  - Conformed Action: drop
  - Exceeded Action: drop
- All classified data flow policers over each Ethernet port feed into a single policer with the following configuration:
  - DATA_AGG, Committed Rate: 10 Mbps
  - Peak Rate: 0 Mbps
  - Committed Action: transmit final
  - Conformed Action: drop
  - Exceeded Action: drop
- Policy IP_POL1 is attached to I1, I2, I3, and I4

Figure 13: Aggregate Rate Limit for Nonvoice Traffic Configuration



1. Create a rate limit that can be shared across all video streams. Create an external parent group to hold this rate limit.

   host1(config)#**rate-limit-profile VIDEO_AGG two-rate hierarchical**
   host1(config-rate-limit-profile)#**committed-rate 1500000**
   host1(config-rate-limit-profile)#**committed-action transmit final**
   host1(config-rate-limit-profile)#**exit**

   host1(config)#**parent-group EPG1**
   host1(config-parent-group)#**rate-limit-profile VIDEO_AGG**
   host1(config-parent-group)#**exit**

2. Create a policy list to attach to all IP sessions.

   host1(config)#**rate-limit-profile VIDEO_RATE two-rate hierarchical**
   host1(config-rate-limit-profile)#**committed-rate 1000000**
   host1(config-rate-limit-profile)#**committed-action transmit conditional**
   host1(config-rate-limit-profile)#**exit**

   host1(config)#**rate-limit-profile DATA_RATE two-rate hierarchical**
   host1(config-rate-limit-profile)#**committed-rate 5000000**
   host1(config-rate-limit-profile)#**committed-action transmit conditional**
   host1(config-rate-limit-profile)#**exit**

```
host1(config)#policy-parameter A hierarchical
host1(config-policy-parameter)#exit
host1(config)#policy-parameter B hierarchical
host1(config-policy-parameter)#exit

host1(config)#ip policy-list IP_POL1
host1(config-policy-list)#classifier-group VIDEO_CLACL external parent-group
EPG1 parameter A
host1(config-policy-list-classifier-group)#rate-limit-profile VIDEO_RATE
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group * external parent-group EPG2
parameter B
host1(config-policy-list-classifier-group)#rate-limit-profile DATA_RATE
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
```

3. In all users' records in RADIUS, specify the ingress policy name IP_POL1. However, be sure to specify the policy parameter through the profile.

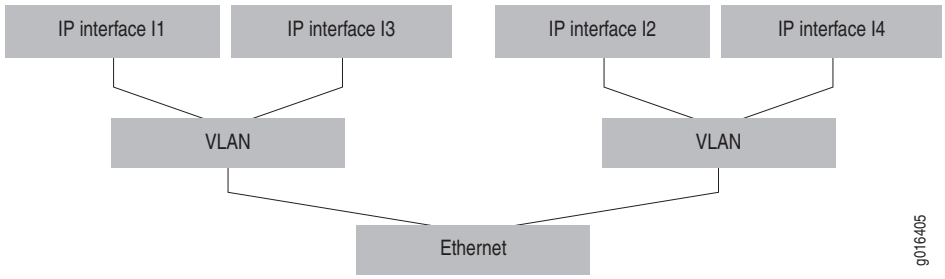
```
host1(config)#profile PPPOE_PROF1
host1(config-profile)#ip policy-parameter hierarchical A vlan
host1(config-profile)#ip policy-parameter hierarchical B ethernet
host1(config-profile)#exit

host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#encapsulation pppoe
host1(config-interface)#profile PPPOE_PROF1
host1(config-interface)#pppoe auto-configure
host1(config-interface)#exit
```

Arbitrary Interface Groups Hierarchical Policy Configuration Example

In this example, there are four terminated sessions and their corresponding IP interfaces are I1, I2, I3, and I4. Figure 14 on page 135 shows the following:

- Sessions I1 and I2 are for the same subscriber: I1 carries only voice traffic and I2 carries all other traffic for this subscriber
- Sessions I3 and I4 are for another subscriber.
- Voice traffic has a contracted minimum of 64 Kbps, but the combined voice and other traffic for each subscriber has a contracted maximum of 1 Mbps.
- Interfaces I1-I4 are interfaces where you can attach policies.

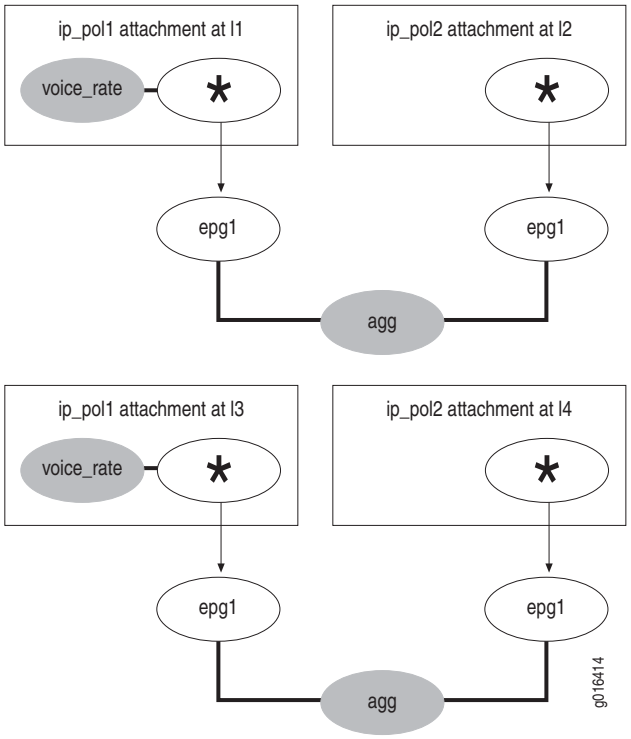
Figure 14: Interface Stack for Arbitrary Interface Groups



This example uses the following:

- At I1 and I3:
  - VOICE_RATE, Committed Rate: 64 Kbps
  - Peak Rate: 0 Mbps
  - Committed Action: transmit unconditional
  - Conformed Action: drop
  - Exceeded Action: drop
- At I2 and I4:
  - No policer configured
  - I1 and I2 feed into a single policer with the following configuration: AGG, Committed Rate: 1 Mbps, Peak Rate: 0 Mbps, Committed Action: transmit, Conformed Action: drop, Exceeded Action: drop

Figure 15: Arbitrary Interface Groups Configuration



1. Create an aggregate rate limit that can be shared across multiple interfaces. Create an external parent group to hold this rate limit.

   host1(config)#**rate-limit-profile AGG two-rate hierarchical**
   host1(config-rate-limit-profile)#**committed-rate 1000000**
   host1(config-rate-limit-profile)#**committed-action transmit final**
   host1(config-rate-limit-profile)#**exit**

   host1(config)#**parent-group EPG1**
   host1(config-parent-group)#**rate-limit-profile AGG**
   host1(config-parent-group)#**exit**

2. Create a policy list to be attached to all voice sessions.

   host1(config)#**rate-limit-profile VOICE_RATE two-rate hierarchical**
   host1(config-rate-limit-profile)#**committed-rate 64000**
   host1(config-rate-limit-profile)#**committed-action transmit unconditional**
   host1(config-rate-limit-profile)#**exit**

   host1(config)#**policy-parameter A hierarchical**
   host1(config-policy-parameter)#**exit**

   host1(config)#**ip policy-list IP_POL1**
   host1(config-policy-list)#**classifier-group * external parent-group EPG1 parameter A**
   host1(config-policy-list-classifier-group)#**rate-limit-profile VOICE_RATE**
   host1(config-policy-list-classifier-group)#**exit**
   host1(config-policy-list)#**exit**

3. Create a policy list to attach to all other sessions.

```
host1(config)#ip policy-list IP_POL2
host1(config-policy-list)#classifier-group * external parent-group EPG1
parameter A
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
```

4. Attach IP_POL1 to the voice session of first user and attach IP_POL2 to the other session for the same user. Specify the same ID for parameter A.

```
host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#exit

host1(config)#interface ip 3/0.1.1
host1(config-interface)#ip policy-parameter hierarchical A 1
host1(config-interface)#ip policy input IP_POL1 statistics enable
host1(config-interface)#exit

host1(config)#interface fastEthernet 3/0.2
host1(config-interface)#vlan id 2
host1(config-interface)#exit

host1(config)#interface ip 3/0.2.1
host1(config-interface)#ip policy-parameter hierarchical A 1
host1(config-interface)#ip policy input IP_POL2 statistics enable
host1(config-interface)#exit
```

5. Attach IP_POL1 to the voice session of the second user and attach IP_POL2 to the other session for the same user. Specify a different ID for parameter A.

```
host1(config)#interface ip 3/0.1.2
host1(config-interface)#ip policy-parameter hierarchical A 2
host1(config-interface)#ip policy input IP_POL1 statistics enable
host1(config-interface)#exit

host1(config)#interface ip 3/0.2.2
host1(config-interface)#ip policy-parameter hierarchical A 2
host1(config-interface)#ip policy input IP_POL2 statistics enable
host1(config-interface)#exit
```

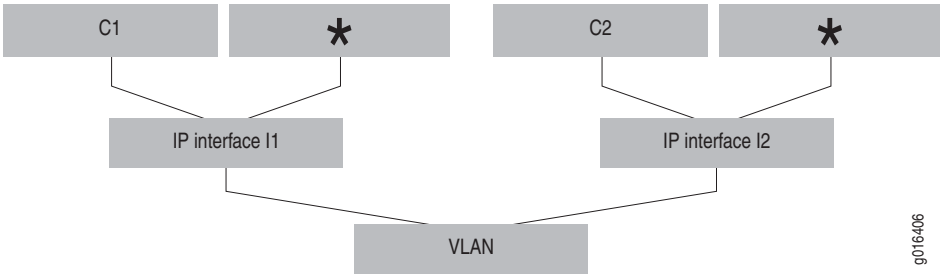
Service and User Rate-Limit Hierarchy Overlap Hierarchical Policy Configuration Example

In the service and user rate-limit hierarchy overlap configuration example:

- The service provider has to enforce a bandwidth limit on a video service over a VLAN and wants to limit the maximum bandwidth of each user's total traffic.
- There are two terminated sessions and their corresponding IP interfaces are I1 and I2.

- Each session contains a video flow classified by C1 and all other traffic is classified by an asterisk (*).
- All video flows over the VLAN are rate-limited to a common rate of 1Mbps.
- Each session is individually rate-limited by 2 Mbps.
- You can attach policies at interface I1-I2.

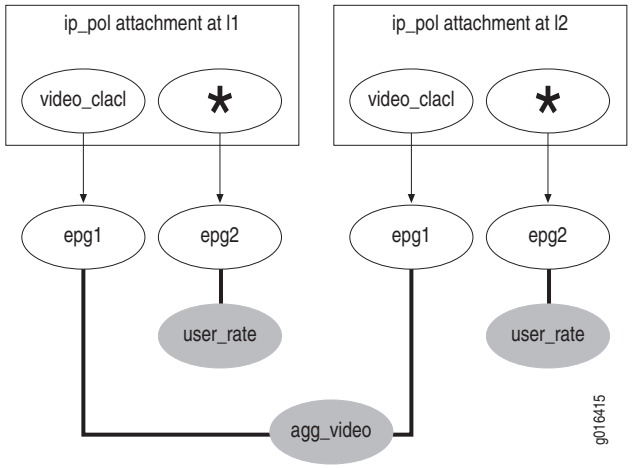
Figure 16: Interface Stack for Service and User Rate-Limit Hierarchy Overlap



This example uses the following:

- At I1 and I2:
  - USER_RATE, Committed Rate: 2 Mbps
  - Peak Rate: 0 Mbps
  - Committed Action: transmit final
  - Conformed Action: drop
  - Exceeded Action: drop
- Both C1 and C2 feed into a single policer with the following configuration:
  - AGG_VIDEO, Committed Rate: 1 Mbps
  - Peak Rate: 0 Mbps
  - Committed Action: transmit conditional
  - Conformed Action: drop
  - Exceeded Action: drop

Figure 17: Service and User Rate-Limit Hierarchy Overlap Configuration



1. Create an aggregate rate limit that can be applied to each IP session. Create an external parent group to hold this rate limit.

   host1(config)#**rate-limit-profile USER_RATE two-rate hierarchical**
   host1(config-rate-limit-profile)#**committed-rate 2000000**
   host1(config-rate-limit-profile)#**committed-action transmit final**
   host1(config-rate-limit-profile)#**exit**

   host1(config)#**parent-group EPG2**
   host1(config-parent-group)#**rate-limit-profile USER_RATE**
   host1(config-parent-group)#**exit**

2. Create an aggregate rate limit that can be shared across multiple video streams. Create an external parent group to hold this rate limit.

   host1(config)#**rate-limit-profile AGG_VIDEO two-rate hierarchical**
   host1(config-rate-limit-profile)#**committed-rate 1000000**
   host1(config-rate-limit-profile)#**committed-action transmit conditional**
   host1(config-rate-limit-profile)#**exit**

   host1(config)#**policy-parameter B hierarchical**
   host1(config-policy-parameter)#**exit**

   host1(config)#**parent-group EPG1**
   host1(config-parent-group)#**next-parent EPG2 parameter B**
   host1(config-parent-group)#**rate-limit-profile AGG_VIDEO**
   host1(config-parent-group)#**exit**

3. Create a policy list to be attached to each IP session.

   host1(config)#**ip classifier-list VIDEO_CLACL udp any any eq 4000**

   host1(config)#**policy-parameter A hierarchical**
   host1(config-policy-parameter)#**exit**

   host1(config)#**ip policy-list IP_POL**
   host1(config-policy-list)#**classifier-group VIDEO_CLACL external parent-group EPG1 parameter A**

```
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group * external parent-group EPG2
parameter B
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
```

4. Attach IP_POL to each IP session. Specify the same ID for parameter A, but a different ID for parameter B.

```
host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#exit

host1(config)#interface ip 3/0.1.1
host1(config-interface)#ip policy-parameter hierarchical A vlan
host1(config-interface)#ip policy-parameter hierarchical B forwarding
host1(config-interface)#ip policy input IP_POL statistics enable
host1(config-interface)#exit

host1(config)#interface ip 3/0.1.2
host1(config-interface)#ip policy-parameter hierarchical A vlan
host1(config-interface)#ip policy-parameter hierarchical B forwarding
host1(config-interface)#ip policy input IP_POL statistics enable
host1(config-interface)#exit
```

Chapter 8

Policy Resources

This chapter provides information about configuring policy resources. The chapter discusses the following topics:

Policy Resources Overview

The maximum number of policies that you can attach to interfaces on an E-series router depends on the classifier entries that make up the policy and the number of attachment resources available on the interface. JUNOSe software allocates interface attachment resources when you attach policies to interfaces. See *Interface Attachment Resources Overview* on page 154 for information about attachment resources.

An E-series router supports software and hardware classifiers. A policy can be made up of any combination of software and hardware classifiers. You use the **classifier-list** command to configure all classifiers.

There are two categories of hardware classifiers, depending on the type of line module being used. OC48/STM16, GE-2, and GE-HDE line modules support content-addressable memory (CAM) hardware classifiers—all other line modules support FPGA hardware classifiers. Table 13 lists the classifiers supported on OC48/STM16, GE-2, and GE-HDE line modules; Table 14 lists the classifiers supported on all other line modules.

Table 13: Classifier Support (OC48/STM16, GE-2, and GE-HDE Line Modules)

Interface Type	Hardware Classifier	Software Classifier
All interface types (except IP and IPv6)	–	■ Color ■ Traffic class ■ User packet class
Frame Relay	Not supported	■ DE bit
GRE tunnels	Not supported	■ ToS
IP	■ Color ■ Destination address ■ Destination port ■ Destination route class ■ ICMP type and code ■ IGMP type ■ IP flags ■ IP fragmentation ■ Local ■ Protocol ■ Source address ■ Source port ■ Source route class ■ TCP flags ■ ToS ■ Traffic class ■ User packet class	Not supported

Table 13: Classifier Support (OC48/STM16, GE-2, and GE-HDE Line Modules)

Interface Type	Hardware Classifier	Software Classifier
IPv6	■ Color ■ Destination address ■ Destination port ■ Destination route class ■ ICMPv6 type and code ■ Local ■ Protocol ■ Source address ■ Source port ■ Source route class ■ TC flags ■ TCP flags ■ Traffic class ■ User packet class	Not supported
MPLS	Not supported	■ EXP
VLAN	Not supported	■ User priority

Table 14: Classifier Support (All Line Modules Except OC48/STM16, GE-2, and GE-HDE)

Interface Type	Hardware Classifier	Software Classifier
All interface types	–	■ Color ■ Traffic class ■ User packet class
Frame Relay	Not supported	■ DE bit
GRE tunnels	Not supported	■ ToS
IP	■ Destination address ■ Destination port ■ ICMP type and code ■ IGMP type ■ Protocol ■ Source address ■ Source port	■ Destination route class ■ IP flags ■ IP fragmentation ■ Local ■ Source route class ■ TCP flags ■ ToS
IPv6	■ Destination address ■ Destination port ■ ICMPv6 type and code ■ Protocol ■ Source address ■ Source port	■ Destination route class ■ Local ■ Source route class ■ TC field ■ TCP flags
MPLS	Not supported	■ EXP
VLAN	Not supported	■ User priority

FPGA Hardware Classifiers

Classification is the process of taking a single data stream in and sorting it into multiple output substreams. The classifier engine on an E-series router is a combination of PowerPC processors, working with an FPGA for a hardware assist.

In the Differentiated Services (DiffServ) architecture, two basic types of classifiers exist. The first classifier type is a multifield (MF) classifier. The MF classifier can examine multiple fields in the IP datagram header to determine the service class to which a packet belongs.

FPGA hardware classifiers are supported on all line modules except the OC48/STM16, GE-2, and GE-HDE line modules. Table 14 lists the FPGA classifiers and software classifiers supported for each interface type.

An E-series router supports two versions of policies that are based on FPGA hardware classifiers. One version has a maximum of 16 classifier entries per policy, and the second version has 17 to 32 classifier entries per policy. The line module supports 16,255 policies when all policies have 16 hardware classifier entries or fewer, and supports 8127 policies when all policies have 17 to 32 hardware classifier entries.

You can configure a combination of the two versions of FPGA hardware classifier-based policies—you can have some that contain 16 or fewer classifier entries and others with more than 16 entries. In this case, between 8127 and 16,255 policies are supported, depending on the actual configuration.

You can also configure hardware classifier-based policies that have more than 32 classifier entries. The router groups the classifiers into blocks of 32. For example, if you configure a policy with 100 classifier entries, the router groups these as 3 policies that have 32 classifier entries and 1 policy with 4 classifier entries. The group with 4 classifier entries actually consumes 16 classifier resources, which is the minimum number consumed for a group in a mixed-mode hardware classifier configuration.

Unlike policies that are based on software classifiers, policies that are based on FPGA hardware classifiers consume resources at a rate of one resource per policy, regardless of the number of different hardware classifier categories in the policy. For example, if a classifier list has three hardware classifiers, such as destination address, source address, and protocol, the policy referencing that classifier list consumes only a single hardware classifier resource.

The same is true when multiple policy rules reference the classifier list. For example, if four policy rules reference the same classifier list (which contains three hardware classifiers), then still only one classifier entry is consumed.

CAM Hardware Classifiers Overview

Content-addressable memory (CAM) hardware classifiers are supported on the OC48/STM16, GE-2, and GE-HDE line modules. Table 13 on page 142 lists CAM hardware classifiers and the software classifiers supported for each interface type.

The OC48/STM16 line module supports 128,000 CAM entries, and the GE-2 and GE-HDE line modules support 64,000 CAM entries. For most configurations, each classifier entry in a policy consumes one CAM entry. However, a policy that has only the default classifier consumes no CAM resources.

In this example, the policy consumes a total of four CAM entries: two entries for clacl1, one for clacl2, and one for the default classifier.

```
host1(config)#ip classifier-list clacl1 ip host 192.168.1.1 host 192.168.2.2 tos 1
host1(config)#ip classifier-list clacl1 ip host 192.168.1.1 host 192.168.2.2 tos 2
host1(config)#ip classifier-list clacl2 tcp any any tcp-flags "SYN"
host1(config)#ip policy-list policy1
host1(config-policy-list)#classifier-group clacl1
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group clacl2
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group *
host1(config-policy-list-classifier-group)#filter
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
host1(config)#
```

A single classifier entry consumes more than one CAM entry when:

- A classifier entry contains a port range. For example:

  ```
  host1(config)#ip classifier-list clacl3 tcp any any range 5 8
  ```

- A classifier entry contains the **not** keyword. Although this keyword is supported for IP classifier lists, we recommend that you not use it—you can usually achieve the desired behavior without this keyword.

  ```
  host1(config)#ip classifier-list clacl4 ip not host 1.1.1.1 any
  ```

In these cases, the actual number of entries that are consumed depends on the configuration.

Size Limit for IP and IPv6 CAM Hardware Classifiers

The maximum width of a CAM hardware classifier entry for IP or IPv6 in a single policy is 128 bits.

Some independent classifiers share the same classifier entry location, while others are combined together to form a larger classifier field. However, you cannot configure any combination of classifiers that exceeds the total classifier entry size of 128 bits.

IP Classifiers and Size Limits

Table 15 lists all IP classifiers and the size limit of each classifier entry.

Table 15: Size Limit of Individual IP Classifiers

IP Classifier	Size Limit (Bits)
Color	2
Destination address	32
Destination port	16
Destination route class	8
ICMP type	8
ICMP code	8
IGMP type	8
IP flags	3
IP fragmentation	2
Local	1
Protocol	8
Source address	32
Source port	16
Source route class	8
TCP flags	6
ToS	8
Traffic class	3
User packet class	4

Table 16 lists the IP classifiers that share the same classifier entry location and those that are combined to form a larger classifier field. The table also lists the rules that apply to these types of classifier combinations.

The format in the classifier entry combinations in Table 16 is based on the conventions for CLI commands, except that the pipe symbol (|) represents a choice of one or both options to the left and right of the pipe symbol.

Table 16: Size Limit of Combined IP Classifiers

IP Classifier Entry Combination	Size Limit (Bits)	Rule
Color or TCP flags or both	8	When you specify one or both of the color and TCP flags classifiers, 8 bits are added to the total classifier entry size.
Destination address	32	–
Destination address route class	8	–
[Destination port] and [[ICMP type] | [ICMP code] | [IGMP type] or nil]	16	The ICMP type, ICMP code, IGMP type, and destination port classifiers share the same classifier field location. When you specify the destination port classifier, 16 bits are added to the total classifier entry size. If you also specify the ICMP type, ICMP code, and IGMP type classifier, no additional bits are added.
[IP flags] | [IP fragmentation] | [Traffic class]	8	When you specify one or more of the IP flags, traffic class, and IP fragmentation classifiers, 8 bits are added to the total classifier entry size.
Protocol	8	–
[Source port] and [[ICMP type] | [ICMP code] | [IGMP type]]	16	The ICMP type, ICMP code, IGMP type, and source port classifiers share the same classifier field location. When you specify the source port classifier, 16 bits are added to the total classifier entry size. When you also specify the ICMP type, ICMP code, and IGMP type classifiers, no additional bits are added.
Source address	32	–
[not Source port] and [not Destination port] and [[ICMP type] | [ICMP code] | [IGMP type]]	16	When you do not specify the source port and destination port classifiers, but you specify one or more of ICMP type, ICMP code, and IGMP type, 16 bits are added to the total classifier entry size. ICMP type, ICMP code, and IGMP type require 16 bits even if the source port and destination port classifications are not configured.
ToS	8	–
User packet class or local or both	8	When you specify one or both of the user packet class and local classifiers, 8 bits are added to the total classifier entry size.

IPv6 Classifiers and Size Limits

Table 17 lists all IPv6 and the size limit of each classifier entry.

Table 17: Size Limit of Individual IPv6 Classifiers

IPv6 Classifier Entry	Size Limit (Bits)
Color	2
Destination address	128
Destination port	16
Destination route class	8
ICMPv6 type	8
ICMPv6 code	8
Local	1
Protocol	8
Source address	128
Source port	16
Source route class	8
TC field	8
TCP Flags	6
Traffic class	3
User packet class	4

Table 18 lists the IPv6 classifiers that share the same classifier entry location and those that are combined to form a larger classifier field. The table also lists the rules that apply to these types of classifier combinations.

The format in the classifier entry combinations in Table 18 is based on the conventions for CLI commands, except that the pipe symbol (|) represents a choice of one or both options to the left and right of the pipe symbol.

Table 18: Size Limit of Combined IPv6 Classifiers

IPv6 Classifier Entry Combination	Size Limit (Bits)	Rule
Color or TCP flags or both	8	When you specify the color and/or TCP flags classifiers, 8 bits are added to the total classifier entry size.
Destination address (first word)	32	–
Destination address (second word)	32	–
Destination address (third word)	32	–
Destination address (fourth word)	32	–
Destination address route class	8	–
[Destination port] and [[ICMPv6 type] | [ICMPv6 code or nil]]	16	When you specify the destination port classifier, 16 bits are added to the total classifier entry size. If you also specify the ICMPv6 type and ICMPv6 code classifiers, no additional bits are added to the total classifier entry size.

Table 18: Size Limit of Combined IPv6 Classifiers (continued)

IPv6 Classifier Entry Combination	Size Limit (Bits)	Rule
[No source port] and [no destination port] and [[ICMPv6 type] | [ICMPv6 code]]	16	When you do not specify the source port and destination port classifiers, and you have already specified one or more of the ICMPv6 Type and ICMPv6 code classifiers, 16 bits are added to the total classifier entry size. The ICMPv6 type and ICMPv6 code classifiers require 16 bits even if you have not specified the source port and destination port classifiers.
Protocol	8	–
Source address (first word)	32	–
Source address (second word)	32	–
Source address (third word)	32	–
Source address (fourth word)	32	–
Source address route class	8	–
[source port] and [[ICMPv6 type] | [ICMPv6 code]]	16	When you specify the source port classifier, 16 bits are added to the total classifier entry size. If you also specify the ICMPv6 type and ICMPv6 code classifiers, no additional bits are added.
TC field	8	–
[User packet class] | [traffic class] | [local]	8	When you specify one or more of the user packet class, traffic class, and local classifiers, 8 bits are added to the total classifier entry size.

Creating and Attaching a Policy with IP Classifiers

In this example, a policy with a combination of IP classifiers is created and attached. The configuration conforms to the 128 bit limit.

1. Match all TCP SYN packets from 1.1.1.1 to any DA with port 2000.

   host1(config)#**ip classifier-list tcpCLACL tcp host 1.1.1.1 any eq 2000 tcp-flags "SYN"**

2. Match all IP packets with the don't fragment flag set to host 2.2.2.2.

   host1(config)#**ip classifier-list ipCLACL ip any host 2.2.2.2 ip-flags "dont-fragment"**

3. Match all ICMP echo packets.

   host1(config)#**ip classifier-list icmpCLACL icmp any any 8 0**

4. Match all frames with the color red.

   host1(config)#**ip classifier-list colorCLACL color red ip any any**

5. Create a policy list.

```
host1(config)#ip policy-list ipPol
host1(config-policy-list)#classifier-group colorCLACL
host1(config-policy-list-classifier-group)#filter
host1(config-policy-list-classifier-group)#classifier-group tcpCLACL
host1(config-policy-list-classifier-group)#filter
host1(config-policy-list-classifier-group)#classifier-group icmpCLACL
host1(config-policy-list-classifier-group)#filter
host1(config-policy-list-classifier-group)#classifier-group ipCLACL
host1(config-policy-list-classifier-group)#filter
```

6. Apply the policy list to an interface.

```
host1(config)#interface atm 5/0.1
host1(config-if)#ip policy input ipPol
```

Table 19 lists the active classifiers in the policy named ipPol and the size of each classifier.

Table 19: Classification Fields for Example 1

Classifiers	Size (Bits)
Source address	32
Destination address	32
Destination port, ICMP type, ICMP code	16
Protocol	8
Color and TCP flags	8
TOS	8
IP flags	8

The total value of the classifiers requested in the ipPol policy is 112, which is less than 128 bit CAM entry size limit.

In this example, a policy with a combination of IP classifiers is created and attached. The configuration exceeds the 128 bit limit.

1. Match all TCP packets from 1.1.1.1 port 10 to 2.2.2.2 port 20.

```
host1(config)#ip classifier-list tcpCLACL tcp host 1.1.1.1 eq 10 host 2.2.2.2 eq
20
```

2. Match all IP fragmentation offset equal to 1.

```
host1(config)#ip classifier-list ipFragCLACL ip any any ip-frag-offset eq 1
```

3. Match all frames with the color red.

```
host1(config)#ip classifier-list colorCLACL color red traffic-class best-effort ip any
any
```

4. Match all frames with UPC 1.

```
host1(config)#ip classifier-group upcCLACL user-packet-class 1 ip any any
```

5. Create a policy list.

```
host1(config)#ip policy-list ipPol
host1(config-policy-list)#classifier-group colorCLACL
host1(config-policy-list-classifier-group)#filter
host1(config-policy-list-classifier-group)#classifier-group ipFragCLACL
host1(config-policy-list-classifier-group)#filter
host1(config-policy-list-classifier-group)#classifier-group igmpCLACL
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#classifier-group lowDelayCLACL
host1(config-policy-list-classifier-group)#traffic-class strict-priority
host1(config-policy-list-classifier-group)#classifier-group tcpCLACL
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#classifier-group *
host1(config-policy-list-classifier-group)#filter
```

6. Apply the policy list to an interface.

```
host1(config)#interface atm 5/0.1
host1(config-if)#ip policy input ipPol
% too many classifier fields in policy
```

Table 20 lists the active classifiers in the policy named ipPol and the size of each classifier.

Table 20: Classification Fields for Example 2

Classifiers	Size (Bits)
Source address	32
Source port	16
Destination port	16
Protocol	8
User packet class	8
Color	8
IP fragmentation	8
ToS	8

The configuration fails because the total value of the classifiers requested in the ipPol policy is 136, which is greater than 128 bit CAM entry size limit.

Software Classifiers Overview

An E-series router supports a variety of software classifiers, depending on the type of interface. Table 13 on page 142 and Table 14 on page 143 list the supported software classifiers for each interface type.

A line module supports 16,383 software classifiers. Software classifiers are consumed at a rate of one resource per classifier category per policy. For example, if you configure a policy that has three different destination route class rules, then because all three rules are for the same classifier category, that policy consumes only one software classifier resource. However, if you configure a policy that requires classification on three different classifier categories, such as ToS, color, and TCP flags, then that policy consumes three of the available 16,383 software classifier resources.

NOTE: Policy consumption is per policy definition per line module.

In this example, the policy list named polWestford5 references four classifier lists with a combination of software and hardware classifiers.

```
host1(config)#ip classifier-list clacl100 color red ip any any
host1(config)#ip classifier-list clacl200 color yellow user-packet-class 6 ip host
10.1.1.1 host 10.1.1.2
host1(config)#ip classifier-list clacl300 color green user-packet-class 5 ip any any
host1(config)#ip classifier-list clacl400 color red ip host 10.1.1.10 any
host1(config)#ip policy-list polWestford5
host1(config-policy-list)#classifier-group clacl100
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group clacl200
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group clacl300
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group clacl400
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group *
host1(config-policy-list-classifier-group)#filter
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
```

For a given line module, the policy list named polWestford5 consumes a total of one FPGA hardware classifier resource and two software classifier resources, as indicated in Table 21.

Table 21: Resource Consumption

Number of Resources Consumed	Classifier Category
1 hardware	■ Protocol ■ Destination address ■ Source address
1 software	Color
1 software	User-packet-class

Interface Attachment Resources Overview

JUNOSe software allocates interface attachment resources when policies are attached to interfaces—when you attach a policy to an interface, the policy consumes one of the interface's attachment resources. Each interface has two attachment resource pools. IP and IPv6 policy attachments are allocated from the interface's IP attachment resource pool; all other attachments are allocated from the interface's layer 2 attachment resource pool.

- The type of line module determines the number of policies attachments supported by interfaces. See *ERX Module Guide, Appendix A, Module Protocol Support* for more information about supported line modules. See *E120 and E320 Module Guide, Appendix A, IOA Protocol Support* for information about the modules that support BGP.
- On ASIC-based line modules (OC48/STM16, GE-2, and GE-HDE line modules), you can have a maximum of 8191 IP policy attachments and 8191 layer 2 policy attachments for ingress policies per forwarding controller, and 8191 IP policy attachments and 8191 layer 2 policy attachments for egress policies per forwarding controller.
- On FPGA-based line modules, you can have a maximum of 8191 IP policy attachments and 8191 layer 2 policy attachments per forwarding controller.

CAM Hardware Classifiers and Interface Attachment Resources

CAM hardware classifiers are supported on OC48/STM16, GE-2, and GE-HDE ASIC-based line modules. Policies that use CAM hardware classifiers consume one interface attachment resource, regardless of the number of classifier entries in a policy.

Range Vector Hardware Classifiers and Interface Attachment Resources

Range vector classifiers, which include all software classifiers and FPGA-based hardware classifiers, consume one interface attachment resource for every 32 classifier entries in a policy.

The following examples illustrate how JUNOSe software allocates interface attachment resources. These examples apply to software and FPGA-based hardware policies:

- A policy with 0 classifier entries consumes 1 interface attachment resource.
- A policy with 1–32 classifier entries consumes 1 interface attachment resource.
- A policy with 33–64 classifier entries consumes 2 interface attachment resources.
- A policy with 65–96 classifier entries consumes 3 interface attachment resources.
- A policy with 487–512 classifier entries consumes 16 interface attachment resources.

Chapter 9

Monitoring Policy Management

This chapter explains how to set a statistics baseline and use the **show** command to display your policy configuration and monitor policy statistics.

This chapter discusses the following topics:

Monitoring Policy Management Overview

You can set a statistics baseline and use the **show** command to display your policy configuration and monitor policy statistics. When you set baseline statistics, you can retrieve statistics beginning at the time when the baselining is set. The policy log rule provides a way to monitor a packet flow by capturing a sample of the packets that satisfy the classification of the rule in the system log. See the *JUNOSe System Event Logging Reference Guide* for information about logging.

NOTE: You can use the output filtering feature of the **show** command to include or exclude lines of output based on a text string you specify. See *JUNOSe System Basics Configuration Guide, Chapter 2, Command-Line Interface* for details.

Setting a Statistics Baseline

You can set a baseline for policy statistics by using the **baseline interface** command and the **atm policy**, **frame-relay policy**, **gre-tunnel policy**, **ip policy, ipv6 policy**, **l2tp policy**, **mpls policy**, and **vlan policy** commands. If you do not enable baselining, **show** command output fields for baseline counters display the contents of the regular statistics counters.

If you enable statistics, you can enable or disable baselining of the statistics. The router implements the baseline by reading and storing the statistics at the time the baseline is set and then subtracting this baseline when baseline-relative statistics are retrieved. Unlike other baseline statistics, policy baseline statistics are not stored in nonvolatile storage (NVS).

If you issue the **baseline interface** command for an interface without first enabling policy statistics baselining on that interface, a warning message indicates that policy baseline statistics are not enabled.

Purpose Enable a baseline for the statistics for the attachment of a policy list with statistics enabled to the ingress of an interface.

Action Enable baseline counters.

host1(config)#**interface atm 12/0.1**
host1(config-subif)#**ip policy input routeForXYZCorp statistics enabled baseline enabled**

Run the **show ip interface** command with the **delta** keyword to show baseline counters:

```
host1#show ip interface atm 12/0.1 delta
atm12/0.1 is up, line protocol is up
  Network Protocols: IP
  Internet address is 200.200.1.1/255.255.255.0
  Broadcast address is 255.255.255.255
  Operational MTU = 9180  Administrative MTU = 0
  Operational speed = 155520000  Administrative speed = 0
  Discontinuity Time = 1251181
  Router advertisement = disabled
  Administrative debounce-time = disabled
```

```
Operational debounce-time    = disabled
Access routing = disabled
Multipath mode = hashed

In Received Packets 5, Bytes 540
In Policed Packets 0, Bytes 0
In Error Packets 0
In Invalid Source Address Packets 0
In Discarded Packets 0
Out Forwarded Packets 5, Bytes 540
Out Scheduler Drops Packets 0, Bytes 0
Out Policed Packets 5, Bytes 540
Out Discarded Packets 0

IP Policy input routeForXYZCorp
  classifier-group *
     filter
     5 Packets  540 Bytes dropped
```

Related Topics

- **atm policy** command
- **frame-relay policy** command
- **gre-tunnel policy** command
- **ip policy** command
- **ipv6 policy** command
- **l2tp policy** command
- **mpls policy** command
- **vlan policy** command

Monitoring the Policy Configuration of ATM Subinterfaces

Purpose Display information about a subinterface's ATM policy lists.

Action To display information about ATM policy lists:

```
host1#show atm subinterface
ATM policy input PolCbr
  classifier-group *
    3096packets, 377678 bytes
    traffic-class best-effort
    color green
```

Meaning Table 22 lists the show **atm subinterface** command output fields.

Table 22: show atm subinterface Output Fields

Field Name	Field Description
ATM policy	Type and name of the ATM policy
mark-clp	CLP bit value, 0 or 1
color	Color applied to packet flow for queuing: green, yellow, or red
classifier-group	Name of the classifier control list used by the policy
filter	Filter policy action
forward	Forward policy action
traffic-class	Traffic class in the policy list
user packet class	User packet class in the policy list

Related Topics

- **show atm interface** command

Monitoring Classifier Control Lists

Purpose Display a list of classifier control lists or details of classifier control lists.

Action To display a list of CLACLs:

```
host1#show classifier-list

                        Classifier Control List Table
                        ---------- ------- ---- -----
GRE Tunnel greClass.1
VLAN lowLatencyLowDrop.1
VLAN excellentEffort.1
VLAN bestEffort.1
VLAN lowLatency.1
IP wstFd.1 source-route-class 44 destination-route-class 55 3 any any
IP XYZCorpPermit.1 local true color green ip any any
IP routeForXYZCorp.1 color red tcp any any
IP XYZCorpIcmpEchoRequests.1 ip any any
IP XYZCorpPrecedence.1 tcp any any tos 5
IP XYZCorpPrecedence67.1 udp any any
IPv6 IPv6Precedence.1 color yellow
IPv6 IPv6Precedence67.1
L2TP l2tpclass.1 color green user-packet-class 8
MPLS mplsClass.1 user-packet-class 10 exp-bits 3 exp-mask 7
Frame relay frMatchDeSet.7 user-packet-class 8 de-bit 0
```

To display details of each CLACL:

```
host1#show classifier-list detailed

                        Classifier Control List Table
                        ---------- ------- ---- -----
IP Classifier Control List XYZCorpPermit
   Reference count:      1
   Entry count:          1

   Classifier-List XYZCorpPermit Entry 1
      Color:                      green
      Protocol:                   ip
      Not Protocol:               false
      Source IP Address:          0.0.0.0
      Source IP WildcardMask:     255.255.255.255
      Not Source Ip Address:      false
      Destination IP Address:     0.0.0.0
      Destination IP WildcardMask:255.255.255.255
      Not Destination Ip Address: false

GRE Tunnel Classifier Control List greClass
   Reference count:      0
   Entry count:          2

   Classifier-List greClass Entry 1
      User Packet Class:          8
      DS Field:                   3

   Classifier-List greClass Entry 2
      Color:                      yellow

VLAN Classifier Control List bestEffort
   Reference count:      0
   Entry count: 1

   Classifier-List bestEffort Entry 1
      Color:                      red
      User Packet Class:          15
      User Priority bits:         7

IPv6 Classifier Control List IPv6Classifier
   Reference count:      0
   Entry count:          1

   Classifier-List IPv6Classifier Entry 1
      User Packet Class:          3
      Traffic Class Field:        200

L2TP Classifier Control List l2tpclass
   Reference count:      0
   Entry count:          1

   Classifier-List l2tpclass Entry 1
      Color:                      green
      User Packet Class:          8

MPLS Classifier Control List mplsClass
   Reference count:      0
   Entry count:          1

   Classifier-List mplsClass Entry 1
```

```
      User Packet Class:          10
      EXP Bits:                   3
      EXP Mask:                   7
Frame relay Classifier Control List frMatchDeSet
   Reference count:      2
   Entry count:          1

   Classifier-List frMatchDeSet Entry 7
      Traffic Class:              toBoston
      User Packet Class:          8
      DE Bit:                     0
```

Meaning Table 23 lists the **show classifier-list** command output fields.

Table 23: show classifier-list Output Fields

Field Name	Field Description
Reference count	Number of times the CLACL is referenced by policies
Entry count	Number of entries in the classifier list
Classifier-List	Name of the classifier list
Entry	Entry number of the classifier list rule
Color	Packet color to match: green, yellow, or red
Protocol	Protocol type
Not Protocol	If true, matches any protocol except the preceding protocol; if false, matches the preceding protocol
Source IP Address	Address of the network or host from which the packet is sent
Source IP WildcardMask	Mask that indicates addresses to be matched when specific bits are set
Not Source Ip Address	If true, matches any source IP address and mask except the preceding source IP address and mask; if false, matches the preceding source IP address and mask
Destination IP Address	Number of the network or host from which the packet is sent
Destination IP WildcardMask	Mask that indicates addresses to be matched when specific bits are set
Not Destination Ip Address	If true, matches any destination IP address and mask except the preceding destination IP address and mask; if false, matches the preceding destination IP address and mask
Traffic Class	Name of the traffic class to match
User Packet Class	User packet value to match
DS Field	DS field value to match
TOS Byte	ToS value to match
Precedence	Precedence value to match
User Priority bits	User priority bits value to match
Traffic Class Field	Traffic class field value to match

Table 23: show classifier-list Output Fields (continued)

Field Name	Field Description
EXP Bits	MPLS EXP bit value to match
EXP Mask	Mask applied to EXP bits before matching
DE Bit	Frame Relay DE bit value to match
Destination Route Class	Route class used to classify packets based on the packet's destination address
Source Route Class	Route class used to classify packets based on the packet's source address
Local	If true, matches packets destined to a local interface; if false, matches packets that are traversing the router

Related Topics

- **show classifier-list** command

Monitoring Color-Mark Profiles

Purpose Display information about color-mark profiles.

Action To display information about color-mark profiles:

```
host1#show color-mark-profile A
                              Color Mark Profile Table
                              ----- ---- ------- -----
IP Color-Mark-Profile: A
    Mask:                          255
    Green mark:                    64
    Yellow mark:                   -
    Red mark:                      8
```

Meaning Table 24 lists the **show color-mark-profile** command output fields.

Table 24: color-mark-profile Output Fields

Field Name	Field Description
Color-Mark-Profile	Name of the color mark profile
filter	Filter policy action

Related Topics

- **show color-mark-profile** command

Monitoring Control Plane Policer Information

Purpose Display information about control plane policer for a specified protocol or all protocols.

Action To display information about control plane policer:

```
host1#show control-plane policer protocol
                                          Burst
                                   Rate   Size   Packets    Packets
          Protocol          Enabled (pps) (pkts) Committed  Exceeded
----------------------------- ------- ----- ------ ---------- ----------
PppEchoRequest                  false    50     50          0          0
PppEchoReply                    false    50     50          0          0
PppEchoReplyFast                false    50     50          0          0
PppControl                      false    50     50          0          0
AtmControl                      false    50     50          0          0
AtmOam                          false    50     50          0          0
AtmDynamicIf                    false    50     50          0          0
AtmInverseArp                   false    50     50          0          0
FrameRelayControl               false    50     50          0          0
FrameRelayArp                   false    50     50          0          0
PppoeControl                    false    50     50          0          0
PppoePppConfig                  false    50     50          0          0
EthernetArp                     false    50     50          0          0
EthernetArpMiss                 false    50     50          0          0
EthernetLacp                    false    50     50          0          0
EthernetDynamicIf               false    50     50          0          0
```

Meaning Table 25 lists the **show control-plane policer** command output fields.

Table 25: show control-plane policer Output Fields

Field Name	Field Description
Protocol	Name of the protocol
Enabled	True or False
Rate (pps)	Rate, in packets per second in the range 0–10000
Burst Size (pkts)	Burst size, in packets, in the range 0–10000
Packets Committed	Number of packets committed
Packets Exceeded	Number of packets exceeded

Related Topics

- **show control-plane policer** command

Monitoring the Policy Configuration of Frame Relay Subinterfaces

Purpose Display information about a subinterface's Frame Relay policy lists.

Action To display information about Frame Relay policy lists:

```
host1#show frame-relay subinterface
Frame relay sub-interface SERIAL5/0:1/1.1, status is up
Number of sub-interface down transitions is 0
Time since last status change 03:04:59
No baseline has been set
  In bytes: 660                    Out bytes: 660
  In frames: 5                     Out frames: 5
  In errors: 0                     Out errors: 0
  In discards: 0                   Out discards: 0
  In unknown protos: 0
Frame relay policy output frOutputPolicy
  classifier-group frGroupA entry 1
     5 packets, 640 bytes
     mark-de 1
Frame relay sub-interface SERIAL5/1:1/1.1, status is up
Number of sub-interface down transitions is 0
Time since last status change 03:05:09
No baseline has been set
  In bytes: 660                    Out bytes: 660
  In frames: 5                     Out frames: 5
  In errors: 0                     Out errors: 0
  In discards: 0                   Out discards: 0
  In unknown protos: 0
Frame relay policy input frInputPolicy
  classifier-group frMatchDeSet entry 1
      5 packets, 660 bytes
      color red
```

Meaning Table 26 lists the **show frame-relay subinterface** command output fields.

Table 26: show frame-relay subinterface Output Fields

Field Name	Field Description
Frame Relay policy	Type and name of the VLAN policy
mark-de	DE bit value
color	Color applied to packet flow for queuing: green, yellow, or red
classifier-group	Name of the classifier control list used by the policy
filter	Filter policy action
forward	Forward policy action
traffic class	Traffic class in the policy list
user-packet-class	User packet class in the policy list

Related Topics

- **show frame-relay subinterface** command

Monitoring GRE Tunnel Information

Purpose Display information about GRE tunnels. The **state** keyword displays tunnels that are in a specific state: **disabled**, **down**, **enabled**, **not-present**, or **up**. The **ip** keyword to display tunnels associated with an IP address. To display information about a specific tunnel, include the name of the tunnel.To display information about tunnels on a specific virtual router, include the name of the virtual router.

Action To display information about GRE Tunnel policy lists:

```
host1#show gre tunnel detail tunnelGre50
GRE tunnel tunnelGre50 is Down
Tunnel operational configuration
  Tunnel mtu is '10240'
  Tunnel source address is '0.0.0.0'
  Tunnel destination address is '0.0.0.0'
  Tunnel transport virtual router is source
  Tunnel checksum option is disabled
  Tunnel sequence number option is disabled
  Tunnel up/down trap is enabled
  Tunnel-server location is 6/0
  Tunnel administrative state is Up
Statistics    packets        octets       discards   errors
  Data rx     0              0            0          0
  Data tx     0              0            0          0
GRE tunnel policy input routeGre25
  classifier-group gre6 entry 1
     0 packets, 0 bytes
     traffic-class best-effort
     mark 4 mask 255
GRE tunnel policy output routeGre35
  classifier-group gre14 entry 1
     0 packets, 0 bytes
     traffic-class best-effort
     mark 4 mask 255
```

Meaning Table 27 lists the **show gre tunnel** command output fields.

Table 27: show gre tunnel Output Fields

Field Name	Field Description
GRE tunnel policy input	Policy for outbound traffic
GRE tunnel policy output	Policy for inbound traffic
traffic-class	Name of traffic class
classifier-group	Name of classifier group
entry	Identifier for the entry in the classifier group
packets	Number of packets
bytes	Number of bytes
mark	ToS byte setting for the classifier control list
mask	Mask value corresponding to the ToS

Related Topics

- **show gre tunnel** command

Monitoring Interfaces and Policy Lists

Purpose Display information about an interface and its policy lists. The **delta** keyword displays baselined statistics and the **brief** keyword displays the operational status of all configured interfaces

Action To display information about interfaces and policy lists:

```
host1#show interfaces fastEthernet 1/0.1
FastEthernet1/0.1 is Up, Administrative status is Up
  VLAN ID: 100

  In: Bytes 4156, Packets 30
   Errors 0, Discards 0
  Out: Bytes 6406, Packets 45
   Errors 0, Discards 0

VLAN policy input vlanPol1
  classifier-group vlan20 entry 1
    5 packets, 730 bytes
    filter

host1#show ip interfaces atm 5/0.2
ATM5/0.2 line protocol Atm1483 is down, ip is down (ready)
  Network Protocols: IP
  Internet address is 2.2.2.2/255.255.255.255
  Broadcast address is 255.255.255.255
  Operational MTU = 0  Administrative MTU = 0
  Operational speed = 100000000  Administrative speed = 0
  Discontinuity Time = 0
  Router advertisement = disabled
  Proxy Arp = disabled
  Network Address Translation is disabled
  TCP MSS Adjustment = disabled
  Administrative debounce-time = disabled
  Operational debounce-time    = disabled
  Access routing = disabled
  Multipath mode = hashed
  Auto Configure = disabled
  Auto Detect = disabled
  Inactivity Timer = disabled

  In Received Packets 0, Bytes 0
    Unicast Packets 0, Bytes 0
    Multicast Packets 0, Bytes 0
  In Policed Packets 0, Bytes 0
  In Error Packets 0
  In Invalid Source Address Packets 0
  In Discarded Packets 0
  Out Forwarded Packets 0, Bytes 0
    Unicast Packets 0, Bytes 0
    Multicast Routed Packets 0, Bytes 0
  Out Scheduler Dropped Packets 0, Bytes 0
  Out Policed Packets 0, Bytes 0
  Out Discarded Packets 0

  IP policy input P
    classifier-group data entry 1
      0 packets, 0 bytes
      rate-limit-profile rlpData
           committed rate: 10000 bps, committed burst: 8192 bytes (default)
```

```
            peak Rate: 100000 bps, peak burst: 1875 bytes
          committed: 0 packets, 0 bytes, action: transmit
          conformed: 0 packets, 0 bytes, action: transmit
          exceeded:  0 packets, 0 bytes, action: drop
      classifier-group voice entry 1
        0 packets, 0 bytes
        rate-limit-profile rlpVoice
            committed rate: 64000 bps, committed burst: 100000 bytes
(default)
            peak Rate: 100000 bps, peak burst: 1875 bytes
          committed: 0 packets, 0 bytes, action: transmit
          conformed: 0 packets, 0 bytes, action: transmit
          exceeded:  0 packets, 0 bytes, action: drop
      classifier-group video entry 1
        0 packets, 0 bytes
        rate-limit-profile rlpVideo
            committed rate: 70000 bps, committed burst: 875 bytes
            peak Rate: 100000 bps, peak burst: 1875 bytes
          committed: 0 packets, 0 bytes, action: transmit
          conformed: 0 packets, 0 bytes, action: transmit
          exceeded:  0 packets, 0 bytes, action: drop
    IP policy output P
      classifier-group data entry 1
        0 packets, 0 bytes
        rate-limit-profile rlpData
            committed rate: 20000 bps, committed burst: 150 bytes
            peak Rate: 200000 bps, peak burst: 3750 bytes
          committed: 0 packets, 0 bytes, action: transmit
          conformed: 0 packets, 0 bytes, action: transmit
          exceeded:  0 packets, 0 bytes, action: drop
      classifier-group voice entry 1
        0 packets, 0 bytes
        rate-limit-profile rlpVoice
            committed rate: 64000 bps, committed burst: 100000 bytes
            peak Rate: 200000 bps, peak burst: 3750 bytes
          committed: 0 packets, 0 bytes, action: transmit
          conformed: 0 packets, 0 bytes, action: transmit
          exceeded:  0 packets, 0 bytes, action: drop
      classifier-group video entry 1
        0 packets, 0 bytes
        rate-limit-profile rlpVideo
            committed rate: 140000 bps, committed burst: 850 bytes
            peak Rate: 200000 bps, peak burst: 3750 bytes
          committed: 0 packets, 0 bytes, action: transmit
          conformed: 0 packets, 0 bytes, action: transmit
          exceeded:  0 packets, 0 bytes, action: drop
```

Meaning Table 28 lists the **show interfaces** command output fields.

Table 28: show interfaces Output Fields

Field Name	Field Description
Subinterface number	Location of the subinterface that carries the VLAN traffic
Administrative status	Operational state that you configured for this interface: up or down
VLAN ID	Domain number of the VLAN
In Bytes	Number of bytes received on the VLAN subinterface

Table 28: show interfaces Output Fields (continued)

Field Name	Field Description
In Packets	Sum of all unicast, broadcast, and multicast packets received on the VLAN or S-VLAN subinterface
In Errors	Value is always 0 (zero)
In Discards	Value is always 0 (zero)
Out Bytes	Number of bytes sent on the VLAN or stacked VLAN (S-VLAN) subinterface
Out Packets	Number of packets sent on the VLAN or S-VLAN subinterface
Out Errors	Value is always 0 (zero)
Out Discards	Value is always 0 (zero)
VLAN policy	Type and name of the VLAN policy

Related Topics

- show interfaces command

Monitoring the Policy Configuration of IP Interfaces

Purpose Display information about an IP interface (including policy list statistics).

Action To display information about IP policy lists:

```
host1#show ip interface serial 2/1:28/24.1
serial2/1:28/24.1 is up, line protocol is up
  Network Protocols: IP
  Internet address is 172.24.1.101/255.255.255.0
  Broadcast address is 255.255.255.255
  Operational MTU = 1600 Administrative MTU = 0
  Operational speed = 155520000  Administrative speed = 0
  Discontinuity Time = 14695
  Router advertisement = disabled
  Administrative debounce-time = disabled
  Operational debounce-time    = disabled
  Access routing = disabled

  In Received Packets 15, Bytes 3135
  In Policed Packets 0, Bytes 0
  In Error Packets 0
  In Invalid Source Address Packets 0
  Out Forwarded Packets 0, Bytes 0
  Out Scheduler Drops Packets 0, Bytes 0

IP Policy input pl28241
Classifier-group clacl28241X01 entry 1
    0 packets, 0 bytes
exception http-redirect
Classifier-group clacl28241X01 entry 1
    0 packets, 0 bytes
    filter
```

```
Classifier-group clacl28241X02 entry 1
  1 packets, 202 bytes
  filter
Classifier-group clacl28241X03 entry 1
  1 packets, 203 bytes
  filter
Classifier-group clacl28241X04 entry 1
  1 packets, 204 bytes
  filter
Classifier-group clacl28241X05 entry 1
  1 packets, 205 bytes
  filter
```

Meaning Table 29 lists the **show ip interfaces** command output fields.

Table 29: show ip interfaces Output Fields

Field Name	Field Description
Network Protocols	Protocols configured on the interface
Internet address	IP address of the interface
Broadcast address	Broadcast address used by the interface
Operational MTU	Operational maximum transmission unit (MTU) for packets sent on this interface
Administrative MTU	Administrative maximum transmission unit for packets sent on this interface
Operational speed	Speed known to the IP layer in bits per second; equal to the administrative speed if configured, otherwise inherited from the lower layer
Administrative speed	Configured speed known to the IP layer in bits per second
Discontinuity Time	Time since the counters on the interface became invalid; for example, when the line module was reset
Router Advertisement	When enabled by the **ip irdp** command, the router advertises its presence via the ICMP Router Discovery Protocol (IRDP)
Administrative debounce-time	Administrative time delay that an interface must remain in a new state before the routing protocols react to the state change
Operational debounce-time	Time delay that an interface must remain in a new state before the routing protocols react to the state change
Access routing	When enabled, an access route is installed to the host on the other end of the interface
In Received Packets	Number of packets received on the interface; indicates whether packets are unicast or multicast
In Received Bytes	Number of bytes received on the interface; indicates whether bytes are unicast or multicast
In Policed Packets	Number of packets policed on the interface; discarded because they exceeded a traffic contract to their destination

Table 29: show ip interfaces Output Fields (continued)

Field Name	Field Description
In Policed Bytes	Number of bytes policed on the interface; discarded because they exceeded a traffic contract to their destination
In Error Packets	Number of packets determined to be in error at the interface
In Invalid Source Address Packets	Number of packets determined to have originated from an invalid source address
Out Forwarded Packets	Number of packets forwarded from the interface; indicates whether packets are unicast or multicast
Out Forwarded Bytes	Number of bytes forwarded from the interface; indicates whether bytes are unicast or multicast
Out Scheduler Drops Packets	Number of packets dropped by the out scheduler; indicates whether packets are committed, conformed, or exceeded
Out Scheduler Drops Bytes	Number of bytes dropped by the out scheduler; indicates whether bytes are committed, conformed, or exceeded
Policy	Indicates which policy is attached and whether it is on the input or output of the interface
classifier-group	Name of a CLACL attached to the interface and number of entry
exception http-redirect	Number of packets and bytes assigned to http-redirect
filter	Number of packets and bytes dropped because of the CLACL
color	Explicit color applied to packet flow for queuing; green, yellow, or red:
Packets logged	Number of packets colored
Bytes logged	Number of bytes colored
next hop	Address of the next-hop destination:
Packets transmitted	Number of packets sent to the next-hop address
Bytes transmitted	Number of bytes sent to the next-hop address
forward	Number of packets and bytes forwarded because of the CLACL
rate-limit-profile	Name of the rate-limit profile
committed	Number of packets and bytes within the committed rate limit
conformed	Number of packets and bytes exceeding the committed rate limit but within the peak rate
exceeded	Number of packets and bytes exceeding the peak rate
action	Action performed on the packets matched by the rules in the rate-limit profile

Related Topics

- show ip interface command

Monitoring the Policy Configuration of IPv6 Interfaces

Purpose Display detailed or summary information, including policy and classifier information, for a particular IPv6 interface or for all interfaces. The default for the **show ipv6 interface** command is all interface types and all interfaces.The **brief** or **detail** keywords with the **show ipv6 interface** command displays different levels of information.

Action To display information about IPv6 policy lists:

```
host1#show ipv6 interface FastEthernet 9/0.6
FastEthernet9/0.6 line protocol VlanSub is up, ipv6 is up
  Description: IPv6 interface in Virtual Router Hop6
  Network Protocols: IPv6
  Link local address: fe80::90:1a00:740:31cd
  Internet address: 2001:db8:1::/48
  Operational MTU 1500 Administrative MTU 0
  Operational speed 100000000 Administrative speed 0
  Creation type Static
  ND reachable time is 3600000 milliseconds
  ND duplicate address detection attempts is 100
  ND neighbor solicitation retransmission interval is 1000 milliseconds
  ND proxy is enabled
  ND RA source link layer is advertised
  ND RA interval is 200 seconds, lifetime is 1800 seconds
  ND RA managed flag is disabled, other config flag is disabled
  ND RA advertising prefixes configured on interface

  In Received Packets 0, Bytes 0
    Unicast Packets 0, Bytes 0
    Multicast Packets 0, Bytes 0
  In Total Dropped Packets 0, Bytes 0
    In Policed Packets 0
    In Invalid Source Address Packets 0
    In Error Packets 0
    In Discarded Packets 0

  Out Forwarded Packets 8, Bytes 768
    Unicast Packets 8, Bytes 768
    Multicast Routed Packets 0, Bytes 0
  Out Total Dropped Packets 5, Bytes 0
    Out Scheduler Dropped Packets 0, Bytes 0
    Out Policed Packets 0
    Out Discarded Packets 5

  IPv6 policy input ipv6InPol25
    rate-limit-profile Rlp2Mb classifier-group clgA entry 1
      Committed: 0 packets, 0 bytes
      Conformed: 0 packets, 0 bytes
      Exceeded:  0 packets, 0 bytes
    rate-limit-profile Rlp8Mb
      Committed: 0 packets, 0 bytes
      Conformed: 0 packets, 0 bytes
      Exceeded:  0 packets, 0 bytes
  IPv6 policy output ipv6PolOut2
    rate-limit-profile RlpOutA classifier-group clgB entry 1
```

```
    Committed: 0 packets, 0 bytes
    Conformed: 0 packets, 0 bytes
    Exceeded:  0 packets, 0 bytes
  rate-limit-profile RlpOutB
    Committed: 0 packets, 0 bytes
    Conformed: 0 packets, 0 bytes
    Exceeded:  0 packets, 0 bytes
IPv6 policy local-input ipv6PolLocIn5
  rate-limit-profile Rlp1Mb classifier-group clgC entry 1
    Committed: 0 packets, 0 bytes
    Conformed: 0 packets, 0 bytes
    Exceeded:  0 packets, 0 bytes
  rate-limit-profile Rlp5Mb
    Committed: 0 packets, 0 bytes
    Conformed: 0 packets, 0 bytes
    Exceeded:  0 packets, 0 bytes
queue 0: traffic class best-effort, bound to ipv6 FastEthernet9/0.6
  Queue length 0 bytes
  Forwarded packets 0, bytes 0
  Dropped committed packets 0, bytes 0
  Dropped conformed packets 0, bytes 0
  Dropped exceeded packets 0, bytes 0
```

Meaning Table 30 lists the **show ipv6 interface** command output fields.

Table 30: show ipv6 interface Output Fields

Field Name	Field Description
Description	Optional description for the interface or address specified
Network Protocols	Network protocols configured on this interface
Link local address	Local IPv6 address of this interface
Internet address	External address of this interface
Operational MTU	Value of the MTU
Administrative MTU	Value of the MTU if it has been administratively overridden using the configuration
Operational speed	Speed of the interface
Administrative speed	Value of the speed if it has been administratively overridden using the configuration
Creation type	Method by which the interface was created (static or dynamic)
ND reachable time	Amount of time (in milliseconds) that the neighbor is expected to remain reachable
ND duplicate address detection attempts	Number of times that the router attempts to determine a duplicate address
ND neighbor solicitation retransmission interval	Amount of time (in milliseconds) during which the router retransmits neighbor solicitations
ND proxy	Whether the router replies to solicitations on behalf of a known neighbor, enabled or disabled
ND RA source link layer	Whether the RA includes the link layer
ND RA interval	Amount of time (in seconds) of the neighbor discovery router advertisement

Table 30: show ipv6 interface Output Fields (continued)

Field Name	Field Description
ND RA lifetime	Amount of time (in seconds) of the neighbor discovery router advertisement
ND RA managed flag	State of the neighbor discovery router advertisement managed flag, enabled or disabled
ND RA other config flag	State of the neighbor discovery router advertisement other config flag, enabled or disabled
ND RA advertising prefixes	Whether advertisement prefixes for neighbor discovery router advertisement are configured
In Received Packets, Bytes	Total number of packets and bytes received on this interface
Unicast Packets, Bytes	Number of unicast packets and bytes received on the IPv6 interface; link-local received multicast packets (non-multicast-routed frames) are counted as unicast packets
Multicast Packets, Bytes	Number of multicast packets and bytes received on the IPv6 interface, which are then multicast-routed and counted as multicast packets
In Total Dropped Packets, Bytes	Total number of inbound packets and bytes dropped on this interface
In Policed Packets	Number of packets that were received and dropped because of rate limits
In Invalid Source Address Packets	Number of packets received with invalid source address (for example, spoofed packets)
In Error Packets	Number of packets received with errors
In Discarded Packets	Number of packets received that were discarded for reasons other than rate limits, errors, and invalid source address
Out Forwarded Packets, Bytes	Total number of packets and bytes that were sent from this interface
Unicast Packets, Bytes	Number of unicast packets and bytes that were sent from this interface
Multicast Routed Packets, Bytes	Number of multicast packets and bytes that were sent from this interface
Out Total Dropped Packets	Total number of outbound packets and bytes dropped by this interface
Out Scheduler Dropped Packets, Bytes	Number of outbound packets and bytes dropped by the scheduler
Out Policed Packets, Bytes	Number of outbound packets and bytes dropped because of rate limits
Out Discarded Packets	Number of outbound packets that were discarded for reasons other than those dropped by the scheduler and those dropped because of rate limits

Table 30: show ipv6 interface Output Fields (continued)

Field Name	Field Description
IPv6 policy	Type (input, output, local-input) and name of the policy
rate-limit-profile	Name of the profile
classifier-group entry	Entry index
Committed	Number of packets and bytes that conform to the committed access rate
Conformed	Number of packets and bytes that exceed the committed access rate but conform to the peak access rate
Exceeded	Number of packets and bytes that exceed the peak access rate
queue, traffic class, bound to ipv6	Queue and traffic class bound to the specified IPv6 interface
Queue length	Number of bytes in the queue
Dropped committed packets, bytes	Total number of committed packets and bytes dropped by this interface
Dropped conformed packets, bytes	Total number of conformed packets and bytes dropped by this interface
Dropped exceeded packets, bytes	Total number of exceeded packets and bytes dropped by this interface

Related Topics

- show ipv6 interface command

Monitoring the Policy Configuration of Layer 2 Services over MPLS

Purpose Display status and configuration information about layer 2 services over MPLS (also known as Martini, or layer 2 transport) on the router or on specific interfaces. Displays only layer 2 circuits for the specified interface.

Action To display information about layer 2 services over MPLS policy lists:

```
host1#show mpls l2transport interface
FastEthernet9/0.1
  routed to 222.9.1.3  on base LSP  tun mpls:lsp-de090100-24-37
  group-id 2 vc-id 900001 mtu 1500
  State UP
  In  Label 48 on stack
    0 pkts, 0 hcPkts, 0 octets
    0 hcOctets, 0 errors, 0 discardPkts

  Out Label 49 on  tun mpls:lsp-de090100-24-37
    0 pkts, 0 hcPkts, 0 octets
    0 hcOctets, 0 errors, 0 discardPkts
    queue 0: traffic class best-effort, bound to atm-vc ATM1/0.1
      Queue length 0 bytes
      Forwarded packets 0, bytes 0
      Dropped committed packets 0, bytes 0
```

```
  Dropped conformed packets 0, bytes 0
  Dropped exceeded packets 0, bytes 0

MPLS policy input mplsInputPolicy
  classifier-group claclWst50 entry 1
    0 packets, 0 bytes
    rate-limit-profile rlp
      committed: 0 packets, 0 bytes, action: transmit
      conformed: 0 packets, 0 bytes, action: transmit
      exceeded:  0 packets, 0 bytes, action drop
MPLS policy output mplsOutputPolicy
  classifier-group claclWst75 entry 1
    0 packets, 0 bytes
    rate-limit-profile rlp
      committed: 0 packets, 0 bytes, action: transmit
      conformed: 0 packets, 0 bytes, action: transmit
      exceeded:  0 packets, 0 bytes, action: drop
```

Meaning Table 31 lists the **show mpls l2transport interface** command output fields.

Table 31: show mpls l2transport interface Output Fields

Field Name	Field Description
Interface	Specifier and status of each interface
base-LSP/remote-addr	Identifies either the tunnel that is selected to forward the traffic or the address of the router at the other end
group-id	Group ID number for the interface
vc-id	VC ID number for the interface
mtu	Maximum transmission unit for the interface
state/in/out-label	Status of the Layer 2-over-MPLS connection or the incoming/outgoing VC label
Mpls Statistics	
pkts	Number of packets received or sent
hcPkts	Number of high-capacity (64-bit) packets received or sent
octets	Number of octets received or sent
hcOctets	Number of high-capacity (64-bit) octets received or sent
errors	Number of packets that are dropped for some reason at receipt or before being sent
discardPkts	Number of packets that are discarded due to lack of buffer space at receipt or before being sent
queue, traffic class, bound to	Queue and traffic class bound to the specified interface
Queue length	Number of bytes in queue
Forwarded packets, bytes	Total number of packets and bytes forwarded by this interface
Dropped committed packets, bytes	Total number of committed packets and bytes dropped by this interface

Table 31: show mpls l2transport interface Output Fields (continued)

Field Name	Field Description
Dropped conformed packets, bytes	Total number of conformed packets and bytes dropped by this interface
Dropped exceeded packets, bytes	Total number of exceeded packets and bytes dropped by this interface
MPLS policy	Type (input, output) and name of policy
classifier-group	Name of a CLACL attached to the interface and number of entry
rate-limit-profile	Name of profile
Committed	Number of packets and bytes conforming to the committed access rate
Conformed	Number of packets and bytes that exceed the committed access rate but conform to the peak access rate
Exceeded	Number of packets and bytes exceeding the peak access rate

Related Topics

- show mpls l2transport interface command

Monitoring External Parent Groups

Purpose Display information about external parent groups.

Action To display information about external parent groups:

```
host1#show parent-group name EPG2

                                    Parent Group Table
                                    ------ ----- ------
Parent Group EPG2
   Reference count: 1
   Rate limit profile: VLAN_RATE
   Next parent group: EPG1 parameter C

   Referenced by policies:
     P1
```

Meaning Table 32 lists the **show parent-group** command output fields.

Table 32: show parent-group Output Fields

Field Name	Field Description
Reference count	Number of references within policies and other external parent groups.
Rate limit profile	Name of hierarchical rate limit profile.
Next parent group	Name of the next parent group and parameter.

Table 32: show parent-group Output Fields (continued)

Field Name	Field Description
Referenced by policies	List of policies where this parent group is referenced.
Referenced by parent groups	List of parent groups where the parent group is referenced.

Related Topics

- show parent-group command

Monitoring Policy Lists

Purpose Display information about policy lists.

Action To display policy lists:

```
host1#show policy-list
                                    Policy Table
                                    ------ -----
IP Policy routeForABCCorp
   Administrative state: enable
   Reference count:      0
     atm-cell-mode: enabled
Classifier control list: ipCLACL10, precedence 75
     exception http-redirect
     forward
Virtual-router: default
         List:
           next-hop 192.0.2.12, order 10, rule 2 (active)
           next-hop 192.0.100.109, order 20, rule 3 (reachable)
           next-hop 192.120.17.5, order 30, rule 4 (reachable)
           interface ip3/1, order 40, rule 5
      mark tos 125
      rate-limit-profile ipRLP25
   Classifier control list: ipCLACL20, precedence 125
      filter

IPv6 Policy routeForIPv6
   Administrative state: enable
   Reference count:      0
   Classifier control list: ipv6tc67, precedence 75
      color red
      mark tc-precedence 7

Frame relay Policy frOutputPolicy
   Administrative state: enable
   Reference count:      0
   Classifier control list: frMatchDeSet, precedence 100
      mark-de 1

Frame relay Policy frInputPolicy
   Administrative state: enable
   Reference count:      0
   Classifier control list: frMatchDeSet, precedence 100
      color red
```

```
GRE Tunnel Policy routeGre50
   Administrative state: enable
   Reference count:      0
   Classifier control list: gre8, precedence 150
      color red
      mark dsfield 20
      filter

L2TP Policy routeForl2tp
   Administrative state: enable
   Reference count:      0
   Classifier control list: *, precedence 100
      color red
      rate-limit-profile l2tpRLP20

MPLS Policy routeForMpls
   Administrative state: enable
   Reference count:      0
   Classifier control list: *, precedence 200
      mark-exp 2 mask 7
      rate-limit-profile mplsRLP5

VLAN Policy routeForVlan
   Administrative state: enable
   Reference count:      0
   Classifier control list: lowLatencyLowDrop, precedence 100
      traffic-class lowLatencyLowDrop
      color green
      mark-user-priority 7
   Classifier control list: lowLatency, precedence 100
      traffic-class lowLatency (suspended)
   Classifier control list: excellentEffort, precedence 100
      traffic-class excellentEffort
   Classifier control list: bestEffort, precedence 100
      traffic-class bestEffort
```

To display component policies:

```
host 1#show policy-list comp_p1

                                  Policy Table
                                  ------ -----
IP Policy comp_p1
   Administrative state: enable
   Reference count:      7
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)
   Classifier control list: C2, precedence 10
      filter

   Referenced by interfaces:
      ATM3/0.3  input policy, statistics enabled, virtual-router vr1
      ATM3/0.4  output policy, statistics disabled, virtual-router vr1
      ATM3/0.5  secondary-input policy, statistics enabled, virtual-router
vr1

   Referenced by profiles:
      prof_1  input policy, statistics disabled
```

```
   Referenced by merge policies:
      mpl_10
      mpl_11
      mpl_12

host1#show policy-list comp_p2

                                  Policy Table
                                  ------ -----
IP Policy comp_p2
   Administrative state: enable
   Reference count:      1
   Classifier control list: C1, precedence 90
      color red
   Classifier control list: *, precedence 1000
      filter

   Referenced by interfaces:
      ATM4/0.5  input policy, statistics enabled, virtual-router default

   Referenced by profiles:
      None

   Referenced by merge policies:
      None
```

To display component policies:

```
host1#show policy-list mpl_10

                                  Policy Table
                                  ------ -----

IP Policy mpl_10
   Administrative state: enable
   Reference count:      1
   Classifier control list: C1, precedence 90
      forward
         Virtual-router: default
         List:
           next-hop 10.1.1.1, order 100, rule 2 (active)
           next-hop 20.1.1.1, order 100, rule 3 (reachable)
   Classifier control list: C2, precedence 10
      filter
   Classifier control list: C3, precedence 10
      filter
   Classifier control list: *, precedence 1000
      forward

   Referenced by interfaces:
      ATM5/0.1  input policy, statistics enabled, virtual-router default

   Referenced by profiles:
      None

   Component policies:
      comp_p1
      comp_p3
```

To display rate limit hierarchy in one policy:

```
host1#show policy-list P1

                                    Policy Table
                                    ------ -----
IP Policy P1
   Administrative state: enable
   Reference count:      2
   Classifier control list: A, precedence 100, parent-group X
      rate-limit-profile A
mark profile A
   Classifier control list: B, precedence 100, parent-group X
      rate-limit-profile B
mark profile B
   Classifier control list: *, precedence 100, parent-group Z
mark profile D
      forward
   Parent group: X, parent-group Z
      rate-limit-profile X
   Parent group: Z
      rate-limit-profile Z

   Referenced by interface(s):
      SERIAL4/0  input policy, statistics disabled, virtual-router default
      SERIAL4/1  input policy, statistics disabled, virtual-router default

   Referenced by profile(s):
      No profile references
```

Meaning Table 33 lists the **show policy list** command output fields.

Table 33: show policy-list Output Fields

Field Name	Field Description
Policy	Name of the policy list.
Administrative state	For SNMP use; state is enabled when the policy list is created. Users modifying the policy list commands via telnet see the state as disabled. Modifications of a policy are not applied to an interface until the administrative state is first disabled and then reenabled.
Reference count	Number of attachments to interfaces or profiles.
Atm cell mode	State of mode for ATM cell tax used in rate calculations.
Referenced by interfaces	List of interfaces to which policy is attached; indicates whether the attachment is at input or output of interface.
Referenced by profiles	List of profiles to which policy is attached; indicates whether the attachment is at input, secondary-input, or output of interface created by the profile.
Referenced by merge policies	List of merged policies.
Referenced by component policies	List of component policies.
Classifier control list	Name of the classifier control list containing policy rules and the precedence assigned to the classifier control list.

Table 33: show policy-list Output Fields (continued)

Field Name	Field Description
Statistics	Enabled, disabled
Parent group	Name of the parent group.
Rule types are:	
filter	Filter policy action
exception http-redirect	HTTP redirect policy action
forward	Forward policy action
next-interface	Next-interface policy action
next-hop	Next-hop policy action
rate-limit-profile	Rate-limit-profile policy action
color	Color of a packet; green, yellow, or red
traffic-class	Traffic class in a policy list
log	Log policy action
mark tos	ToS byte in the IP header to a specified value
mark DS field	DS field value in the IP header to a specified value
mark TC precedence	Traffic class value in the IPv6 header to a specified value
mark EXP	Value assigned to EXP bits action
mark user priority	Value assigned to 802.1p VLAN user priority bit
mark DE	DE bit action
Rule status	Indicates whether the rule is suspended.

Related Topics

- show policy-list command

Monitoring Policy List Parameters

Purpose Display information about policy list parameters.

Action To display policy list information for a hierarchical policy:

```
host1#show policy-parameter
Policy Parameter hierGroup1
    Type: hierarchical
    Reference count: 8
    Aggregation node: vlan
    Referenced by interfaces: 2 references
      IP ATM5/0.1: atm-vc
      IP ATM5/0.2: 5

    Referenced by profiles: 1 references
      profile1

    Referenced by policies: 5 references
      policy1
```

```
      policy2
      policy3
Policy Parameter hierGroup2
    Type: hierarchical
    Reference count: 3
    Aggregation node: 3
    Referenced by interfaces: 1 references
      IP ATM5/0.2: atm-vp 1

    Referenced by policies: 2 references
      policy1

    Referenced by parent groups: 1 references
      extPg1
```

To dislay list information:

```
host1(config)#show policy-parameter

                            Policy Parameter Table
                            ------ --------- -----
Policy Parameter refRlpRate
    Type: reference-rate
    Rate: 100000
    Reference count: 7
    Referenced by interfaces: 2 references
      IP interface ATM5/0.1: 1000000
      IP interface ATM5/0.2: 200000

    Referenced by rate-limit profiles: 5 references
      rlpData
      rlpVoice
      rlpVideo

Policy Parameter otherRate
    reference-rate: 65536
    Reference count: 3
    Referenced by interfaces: 1 references
      IP interface ATM5/0.2: 100000

    Referenced by rate-limit profiles: 2 references
      rlpOther
```

Meaning Table 34 lists the **show policy-parameter** command output fields.

Table 34: show policy-parameter Output Fields

Field Name	Field Description
Type	Type of parameter, such as hierarchical.
Reference count	Number of references in policy, interface, and external parent group profiles.
Aggregation node	Aggregation node value.
Referenced by interfaces	List of interfaces where parameter is referenced.
Referenced by profiles	List of profiles where parameter is referenced
Referenced by policies	List of policies where parameter is referenced.
Referenced by parent groups	List of external parent groups where parameter is referenced.

Related Topics

- **show policy-parameter** command

Monitoring Rate-Limit Profiles

Purpose Display information about rate-limit profiles.

Action To display information about rate-limit profiles:

```
host1#show rate-limit-profile
                            Rate Limit Profile Table
                            ---- ----- ------- -----
IP Rate-Limit-Profile: rlp
   Profile Type:                  one-rate
   Reference count:               0
   Committed rate:                0
   Committed burst:               8192
   Excess burst:                  0
   Mask:                          255
   Committed rate action:         transmit
   Conformed rate action:         transmit
   Exceeded rate action:          drop
IP Rate-Limit-Profile: rlp
   Profile Type:                  two-rate hierarchical
   Color-aware                    no
   Reference count:               0
   Committed rate:                0
   Committed burst:               8192
   Peak rate:                     0
   Peak burst:                    8192
   Mask:                          255
   Committed rate action:         transmit unconditional
   Conformed rate action:         transmit conditional
   Exceeded rate action:          drop
L2TP Rate-Limit-Profile: L2tpRlp
   Profile Type:                  two-rate
   Reference count:               0
   Committed rate:                0
   Committed burst:               8192
   Peak rate:                     0
   Peak burst:                    8192
   Committed rate action:         transmit
   Conformed rate action:         transmit
   Exceeded rate action:          drop
```

Meaning Table 35 lists the **show rate-limit-profile** command output fields.

Table 35: show rate-limit-profile Output Fields

Field Name	Field Description
Rate-Limit-Profile	Create a rate limit profile
Profile Name	Name of the rate-limit profile
Profile Type	One-rate, two-rate, or hierarchical profile
Reference count	Number of policy lists that reference this rate-limit profile

Table 35: show rate-limit-profile Output Fields (continued)

Field Name	Field Description
Color-aware	Color-aware action (yes or no) taken for profile
Committed rate	Target rate for the traffic, in bits per second
Committed burst	Amount of bandwidth allocated to accommodate bursty traffic, in bytes
Excess burst	Amount of bandwidth allocated to accommodate a packet in progress when the rate is in excess of the burst, in bytes
Peak rate	Amount of bandwidth allocated to accommodate traffic flow in excess of the committed rate, in bits per second
Peak burst	Amount of bandwidth allocated to accommodate bursty traffic in excess of the peak rate, in bytes
Mask	Value of mask applied to ToS byte in IP packet header
Committed rate action	Policy action (drop, transmit, or mark) taken when traffic flow does not exceed the committed rate
Conformed rate action	Policy action (drop, transmit, or mark) taken when traffic flow exceeds the committed rate but remains below the peak rate
Exceeded rate action	Policy action (drop, transmit, or mark) taken when traffic flow exceeds the peak rate

Related Topics

- **show rate-limit-profile** command

Monitoring the Policy Configuration of VLAN Subinterfaces

Purpose Display information about a subinterface's VLAN policy lists.

Action To display information about VLAN policy lists:

```
host1#show vlan subinterface fastEthernet 1/0.1
VLAN ID is 100
VLAN policy input vlanPol1
  classifier-group claclVlanBos entry 1
    5 packets, 730 bytes
    filter
```

Meaning Table 36 lists the **show vlan subinterface** command output fields.

Table 36: show vlan subinterface Output Fields

Field Name	Field Description
Subinterface number	Location of the subinterface that carries the VLAN traffic
VLAN ID	Domain number of the VLAN

Table 36: show vlan subinterface Output Fields (continued)

Field Name	Field Description
VLAN policy	Type and name of the VLAN policy
filter	Number of packets and bytes that have been policed by the policy

Related Topics

- show vlan subinterface command

Packet Flow Monitoring Overview

The policy log rule provides a way to monitor a packet flow by capturing a sample of the packets that satisfy the classification of the rule in the system log. See the *JUNOSe System Event Logging Reference Guide* for information about logging.

To capture the interface, protocol, source address, destination address, source port, and destination port, set the policyMgrPacketLog event category to log at severity info and at low verbosity. To capture the version, ToS, len ID, flags, time to live (TTL), protocol, and checksum in addition to the information captured at low verbosity, set the verbosity to medium or high.

When the policy is configured, all packets are examined and the matching packets are placed in the log. No more than 512 packets are logged every 3 seconds. The router maintains a count of the total number of matching packets. This count is incremental even if the packet cannot be stored in the log (for example, because the count exceeds the 512-packet threshold).

This example shows how you might use classification to specify the ingress packets that are logged on an interface.

```
host1(config)#ip policy-list testPolicy
host1(config-policy-list)#classifier-group logA
host1(config-policy-list-classifier-group)#log
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
host1(config)#interface atm 0/0.0
host1(config-subif)#ip policy input testPolicy statistics enabled
host1(config-subif)#exit
host1(config)#log destination console severity info
host1(config)#log severity info policyMgrPacketLog
host1(config)#log verbosity low policyMgrPacketLog
host1(config)#log here
```

This example provides a more detailed procedure that an ISP might use to log information during a ping attack on the network. The procedure includes the creation of the classifier and policy lists to specify the desired packet flow to monitor, the logging of the output of the classification operation, and the output of the **show** command.

In this example, a customer has reported to their ISP that an attack is occurring on their internal servers. The attack is a simple ping flood.

1. The ISP creates a classifier list to define an ICMP echo request packet flow.

```
host1:vr2(config)#ip classifier-list icmpEchoReq icmp any any 8 0
host1:vr2(config)#ip policy-list pingAttack
host1:vr2(config-policy-list)#classifier-group icmpEchoReq
host1:vr2(config-policy-list-classifier-group)#log
host1:vr2(config-policy-list-classifier-group)#exit
host1:vr2(config-policy-list)#exit

host1:vr2(config)#interface gigabitEthernet 2/0
host1:vr2(config-if)#ip address 10.10.10.2 255.255.255.0
host1:vr2(config-if)#exit

host1:vr2(config)#virtual-router vr1
host1:vr1(config)#interface gigabitEthernet 0/0
host1:vr1(config-if)#ip address 10.10.10.1 255.255.255.0
host1:vr1(config-if)#ip policy input pingAttack statistics enabled
host1:vr1(config-if)#exit
host1:vr1(config)#exit
```

2. The ISP configures standard logging on the E-series router.

```
host1(config)#log destination console severity info
host1(config)#log severity info policyMgrPacketLog
host1(config)#log here

INFO 12/16/2003 12:59:47 policyMgrPacketLog ():
icmpEchoReq icmp GigabitEthernet0/0 10.10.10.2 10.10.10.1 forwarded
INFO 12/16/2003 12:59:47 policyMgrPacketLog ():
icmpEchoReq GigabitEthernet0/0 number of hits = 21551
INFO 12/16/2003 12:59:50 policyMgrPacketLog ():
icmpEchoReq icmp GigabitEthernet0/0 10.10.10.2 10.10.10.1 forwarded
INFO 12/16/2003 12:59:50 policyMgrPacketLog ():
icmpEchoReq GigabitEthernet0/0 number of hits = 21851
INFO 12/16/2003 12:59:53 policyMgrPacketLog ():
icmpEchoReq icmp GigabitEthernet0/0 10.10.10.2 10.10.10.1 forwarded
INFO 12/16/2003 12:59:53 policyMgrPacketLog ():
icmpEchoReq GigabitEthernet0/0 number of hits = 22151
```

3. The ISP displays statistics for the interface.

```
host1:vr1#show ip interface gigabitEthernet 0/0
GigabitEthernet0/0 line protocol Ethernet is up, ip is up
  Network Protocols: IP
  Internet address is 10.10.10.1/255.255.255.0
  Broadcast address is 255.255.255.255
  Operational MTU = 1500  Administrative MTU = 0
  Operational speed = 1000000000  Administrative speed = 0
  Discontinuity Time = 1092358
  Router advertisement = disabled
  Proxy Arp = enabled
  Network Address Translation is disabled
  Administrative debounce-time = disabled
  Operational debounce-time    = disabled
  Access routing = disabled
  Multipath mode = hashed
  Auto Configure = disabled
  Auto Detect = disabled
  Inactivity Timer = disabled
```

```
In Received Packets 488421, Bytes 62517888
  Unicast Packets 488421, Bytes 62517888
  Multicast Packets 0, Bytes 0
In Policed Packets 0, Bytes 0
In Error Packets 0
In Invalid Source Address Packets 0
In Discarded Packets 0
Out Forwarded Packets 486152, Bytes 62232048
  Unicast Packets 486152, Bytes 62232048
  Multicast Routed Packets 0, Bytes 0
Out Scheduler Dropped Packets 0, Bytes 0
Out Policed Packets 0, Bytes 0
Out Discarded Packets 2269

IP policy input pingAttack
  classifier-group icmpEchoReq entry 1
    488421 packets, 69355782 bytes
    log

queue 0: traffic class best-effort, bound to ip GigabitEthernet0/0
  Queue length 0 bytes
  Forwarded packets 485988, bytes 70954248
  Dropped committed packets 0, bytes 0
  Dropped conformed packets 0, bytes 0
  Dropped exceeded packets 0, bytes 0
```

Part 2

Packet Mirroring

Chapter 10

Packet Mirroring Overview

This chapter contains the following sections:

Packet Mirroring Overview

Packet mirroring enables you to send a copy of a packet to an external host for analysis. Packet mirroring has many uses, including traffic debugging and troubleshooting user networking problems.

The JUNOSe software provides two methods that you can use to configure and manage your packet mirroring environment—CLI-based and RADIUS-based.

- CLI-based packet mirroring—An authorized user uses the router's CLI commands to configure and manage packet mirroring. You can mirror traffic related to a specific IP or L2TP interface or traffic related to a particular user. You also use CLI commands to create secure policies that identify the traffic to be mirrored and specify how the mirrored traffic is treated.

- RADIUS-based packet mirroring—A RADIUS administrator uses RADIUS attributes to configure packet mirroring of a particular user's traffic. The router creates dynamic secure policies for the mirroring operation.

In both the CLI-based and the RADIUS-based packet mirroring methods, the original traffic is sent to its intended destination and the mirrored traffic is sent to an analyzer (the mediation device). The mirroring operations are transparent to the user whose traffic is being mirrored.

NOTE: Packet mirroring operations require some system resources. To avoid performance degradation, limit the amount of mirrored traffic to a maximum of 5 percent of the E-series router's total traffic.

Packet mirroring is supported on ASIC-based modules. See *ERX Module Guide, Appendix A, Module Protocol Support* for information about modules supported on ERX routers. See *E120 and E320 Module Guide, Appendix A, IOA Protocol Support* for information about modules supported on the E120 and E320 routers.

Comparing CLI-Based Mirroring and RADIUS-Based Mirroring

This section compares the characteristics of CLI-based and RADIUS-based mirroring techniques. You can use CLI-based mirroring for both interface-specific and user-specific mirroring; RADIUS-based mirroring is used for user-specific mirroring. This section highlights differences in configuration, security, and application of the CLI-based and RADIUS-based mirroring methods.

Configuration

This section describes differences in the configuration processes for CLI-based and RADIUS-based mirroring:

- CLI-based packet mirroring—You use CLI commands to configure and manage packet mirroring of specific interfaces and users. For interface-specific mirroring, you enable the static configuration after the IP interface is created. The interface method mirrors only the traffic on the specific interface.

  In user-specific mirroring, authentication, authorization, and accounting (AAA) uses RADIUS attributes as triggers to identify the user whose traffic is to be mirrored. The mirroring session starts when the user logs on. If the user is already logged in, AAA immediately starts the mirroring session when you enable packet mirroring.

- RADIUS-based packet mirroring—This dynamic method uses RADIUS and vendor-specific attributes (VSAs), rather than CLI commands, to identify a user whose traffic is to be mirrored and to trigger the mirroring session. A RADIUS administrator configures and enables the mirroring separate from the user's session. You can use a single RADIUS server to provision packet mirroring operations on multiple E-series routers in a service provider's network.

  There are two variations of RADIUS-based packet mirroring. For both types, the mirroring feature is initiated without regard to the user location, router, interface, or type of traffic.

  - User-initiated mirroring—If the user is not currently logged in, the mirroring session starts when the user logs on and is authenticated by RADIUS.

  - RADIUS-initiated mirroring—If the user is already logged in, the JUNOSe RADIUS dynamic-request server uses RADIUS-initiated change-of-authorization (CoA) messages to immediately start the mirroring session when the packet mirroring is enabled.

NOTE: Packet mirroring is not supported on IPv6 interfaces.

Security

The following list highlights security features provided by CLI-based and RADIUS-based mirroring:

- CLI-based packet mirroring—All packet mirroring commands are hidden by default. You must execute the **mirror-enable** command to make the mirroring commands visible. You can optionally configure authorization methods to control access to the **mirror-enable** command, which makes the packet mirroring commands available only to authorized users. The **mirror-enable** command is in privilege level 12 by default and the mirroring commands are in privilege level 13 by default. You can change the privilege levels of these commands; however, we recommend that you always put the **mirror-enable** command at a different privilege level than the mirroring commands.

- RADIUS-based packet mirroring—Access to RADIUS-based mirroring functionality is unrestricted. However, the display of mirroring functionality is restricted to privilege level 13 users by default. In addition, the user must execute the **mirror-enable** command to make the packet mirroring-related **show** commands visible.

  RADIUS-based mirroring uses dynamically created secure policies based on certain RADIUS VSAs. You attach the secure policies to the interface used by the mirrored user. The packet mirroring VSAs that the RADIUS server sends to the E-Series router are MD5 salt-encrypted.

Application

The following list compares the different types of packet mirroring methods:

- CLI-based packet mirroring—Is useful when organizations want to provide separation between the typical network operations personnel and the mirroring operations personnel. For example, if security is essential, you might perform the entire packet-mirroring configuration on the mediation device, separate from the normal network operations role. This way, only the authorized personnel on the mediation device are aware of the mirroring operation. If this level of security is not required, the network operations personnel can perform the configuration and management on the router as usual.

  - CLI-based interface-specific mirroring—Can be useful in small networks with few E-series routers and in static environments where a user typically logs on to the same router through the same interface.
  - CLI-based user-specific mirroring—Is useful in B-RAS environments, in which users log in and log out frequently.

- RADIUS-based user-specific mirroring—Is triggered when needed, either user-initiated when the specified user logs on, or RADIUS-initiated when the user is already logged in. RADIUS-based mirroring also provides an excellent solution for B-RAS networks, for example to troubleshoot traffic problems related to mobile users.

CLI-based user-specific and RADIUS-based user-specific mirroring are also useful to mirror L2TP traffic at the L2TP access concentrator (LAC). If the L2TP network server (LNS) and the LAC belong to different service providers, mirroring at the LAC enables mirroring to take place close to the user's domain.

Packet Mirroring Terms

Table 37 defines terms used in this discussion of packet mirroring.

Table 37: Packet-Mirroring Terminology

Term	Meaning
Analyzer device	Device that receives the mirrored traffic from the E-series router. Also called the mediation device.
Analyzer interface	IP interface in analyzer mode on the E-series router that is used to direct mirrored traffic to the analyzer device.
CLI access class	Security level that grants access to specific CLI commands.
Mirrored interface	Statically or dynamically configured interface on which traffic is being mirrored.
Mirrored user	User whose traffic is being mirrored.
Requesting authority	Group that is authorized to request or conduct packet mirroring.
Salt encryption	Random string of data used to modify a password hash.
Secure policy	Policies created with a mirror action and that contain information about where to forward mirrored traffic.
Trigger	RADIUS attribute that identifies a user whose traffic is to be mirrored. Packet mirroring starts when a trigger is detected. An E-series router supports a maximum of 100 mirror trigger rules.

Packet Mirroring Platform Considerations

For information about modules that support packet mirroring on ERX-14xx models, ERX-7xx models, and the ERX-310 router:

- See *ERX Module Guide, Chapter 1, Module Combinations* for detailed module specifications.
- See *ERX Module Guide, Appendix A, Module Protocol Support* for information about the modules that support packet mirroring.

For detailed information about the modules that support packet mirroring on the E120 router and the E320 router:

- See *E120 and E320 Module Guide, Chapter 1, Modules and IOAs* for detailed module specifications.
- See *E120 and E320 Module Guide, Appendix A, IOA Protocol Support* for information about the protocols and applications that support packet mirroring.

Packet Mirroring References

For more information about RADIUS-based packet mirroring, consult the following resources:

- RFC 3576—Dynamic Authorization Extensions to Remote Authentication Dial In User Service (RADIUS) (July 2003)
- Lawfully Authorized Electronic Surveillance (LAES) for IP Network Access, American National Standard for Telecommunications, version PTSC-LAES-2006-084R6

Chapter 11

Configuring CLI-Based Packet Mirroring

This chapter contains the following sections:

CLI-Based Packet Mirroring Overview

Packet mirroring enables you to send a copy of a packet to an external host for analysis. Packet mirroring has many uses, including traffic debugging and troubleshooting user networking problems.

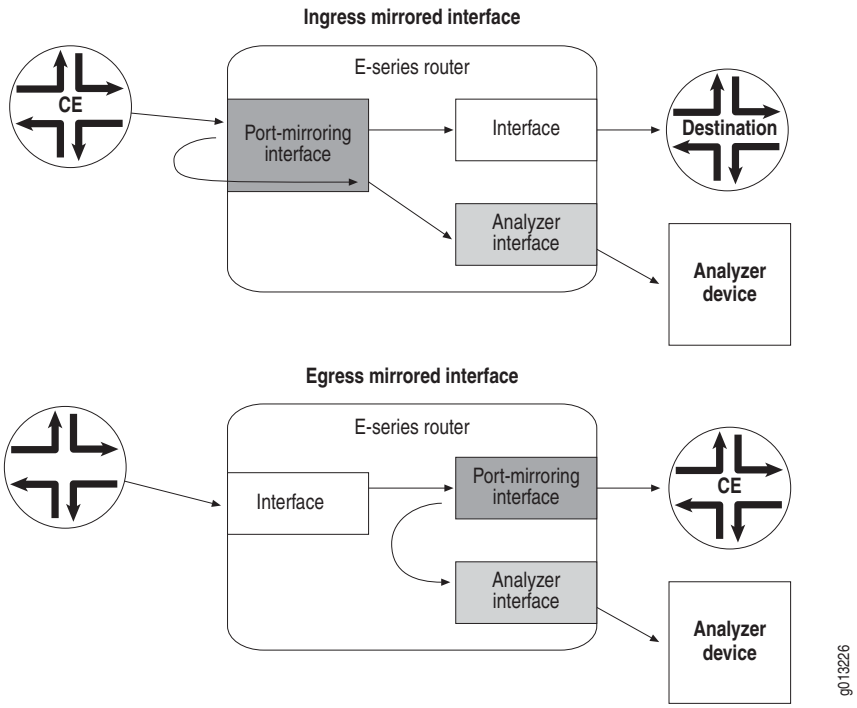
The JUNOSe software enables you to use CLI commands to configure and manage packet mirroring on specific static IP interfaces, or for a specific user. You use CLI commands to create a secure policy that specifies the analyzer device and how the mirrored traffic is treated.

When you mirror an interface, you can replicate ingress and egress traffic on the interface (traffic entering or exiting the E-series router through that interface). When you mirror a user, you can replicate all traffic to or from the user.

In both interface-specific and user-specific mirroring, the original traffic is forwarded to its intended destination as usual, while the replicated copy of the traffic is forwarded to an analyzer interface on the E-series router. The analyzer interface then directs the mirrored traffic to the specified analyzer device for analysis.

Figure 18 shows the traffic flow for ingress and egress IP interface mirroring.

Figure 18: CLI-Based Interface Mirroring



Enabling and Securing CLI-Based Packet Mirroring

The JUNOSe software enables you to create a secure environment for your packet mirroring operation by restricting access to the packet mirroring CLI commands and information. For example, when dealing with a critical diagnostic or troubleshooting procedure, you might want the packet mirroring feature to be available and visible to a subset of your network operations group. Or, if you are monitoring confidential traffic from a particular user, you might want the configuration and results of the mirroring operation to be available only to a unique group, such as the management group of the analyzer device.

By default, the packet mirroring configuration commands are hidden from all users. You must use the **mirror-enable** command to make the commands visible, which then enables you to configure the packet mirroring environment. The command applies only to the current CLI session. When you log off the current session and then log on again, the packet mirroring commands are no longer visible,

NOTE: The **no mirror-enable** command makes the packet mirroring commands no longer visible. However, any active mirroring sessions are unaffected and traffic continues to be mirrored.

To create a secure packet mirroring environment, you use a combination of the JUNOSe software authorization methods and the **mirror-enable** command. You configure the authorization method to control who can use the **mirror-enable** command. Authorized users can then issue the **mirror-enable** command, making the packet mirroring commands visible. However, the commands are still hidden from unauthorized users. Table 38 lists the commands whose visibility is controlled by the **mirror-enable** command.

Table 38: Commands Made Visible by the mirror-enable Command

■ ip policy { secure-input | secure-output }	■ show ip interface (packet mirroring information)
■ clear mirror log	■ show mirror log
■ mirror acct-session-id	■ show mirror rules
■ mirror analyzer-ip-address	■ show mirror trap
■ mirror calling-station-id	■ show mirror subscribers
■ mirror disable	■ show secure classifier-list
■ mirror ip-address	■ show secure policy-list
■ mirror nas-port-id	■ show snmp secure-log
■ mirror trap-enable	■ show snmp trap (packet mirroring information)
■ mirror username	■ snmp-server clear secure-log
■ secure ip classifier-list	■ snmp-server secure-log
■ secure ip policy-list	■ snmp-server enable traps (packetMirror keyword)
■ secure l2tp policy-list	■ snmp-server host (packetMirror keyword)

To provide increased security, the **mirror-enable** command must be the only command at its access level (level 12 by default) and it also must be at a different privilege level than the other packet mirroring commands (level 13 by default) and other regular JUNOSe CLI commands. This separation enables you to control authorization to the **mirror-enable** command and to limit the visibility of packet mirroring commands. For example, if you are using TACACS+, the **mirror-enable** command is the only packet mirroring command that is sent to the TACACS+ server. You can also use TACACS+ to prevent unauthorized individuals from modifying the configuration of analyzed ports.

The following two examples describe techniques you might use to enable and secure your CLI-based packet mirroring environment. Example 1 uses a combination of TACACS+ authorization and virtual terminal (vty) access lists to secure the packet mirroring environment. Example 2 uses only vty access lists.

See *JUNOSe System Basics Configuration Guide, Chapter 9, Passwords and Security* for more information about access levels. See *JUNOSe Broadband Access Configuration Guide, Chapter 9, Configuring TACACS+* for information about TACACS+ authorization.

Reloading a CLI-Based Packet Mirroring Configuration

You can reload your packet mirroring configuration as part of a configuration file (.cnf) reload operation or when you run a script file (.scr) that you have saved from the **show configuration** command display. When you reload a .cnf file, the packet mirroring configuration is restored—no additional steps are required.

For a .scr file operation, the **mirror-enable** command must be enabled—before saving the scr. file from the **show configuration** display, and also before you run the script to reload the packet mirroring configuration. If the **mirror-enable** command is not enabled, the .scr file operation for the packet mirroring configuration fails.

Using TACACS+ and Vty Access Lists to Secure Packet Mirroring

The following example describes a procedure that uses TACACS+ and vty access lists to manage the users who have access to the **mirror-enable** command. An authorized user who issues the **mirror-enable** command then gains access to the packet mirroring CLI commands and information.

This technique enables you to restrict the visibility and use of packet mirroring commands to a controlled, authorized group of users.

1. Configure TACACS+ authorization for the access level of the **mirror-enable** command (level 12 by default).

   Configure the router either to allow or disallow authorization when the TACACS+ servers are not available.

2. Configure all vty lines and the console to use the TACACS+ authorization configuration from Step 1 for access level 12 commands.

This procedure ensures that packet mirroring commands are never sent out of the E-series router—only the **mirror-enable** command is sent. The packet mirroring configuration and all information about mirrored interfaces and subscribers are available only to users who are authorized for the packet mirroring CLI commands on the router.

Using Vty Access Lists to Secure Packet Mirroring

In this example, TACACS+ authorization is not used. However, you can still use vty access lists to control access to the **mirror-enable** command, which enables you to create isolation between the authorized packet mirroring users and unauthorized network operators.

1. Configure TACACS+ authorization for the **mirror-enable** command privilege level. Specify that authorization is denied if TACACS+ is not available. Because TACACS+ is not being used, authorization always fails.

2. Configure the *majority* of the vty lines and the console to use the authorization configuration from Step 1. (Users who use Telnet on these lines are denied access to the **mirror-enable** command.)

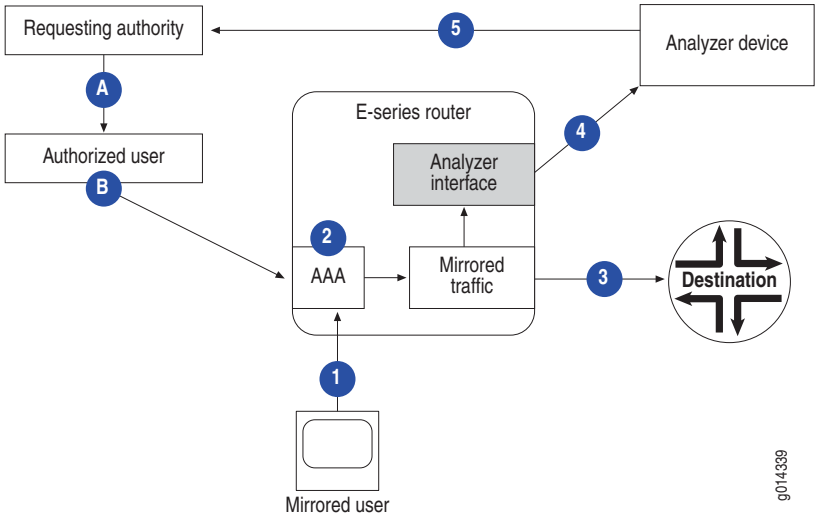
3. On the remaining vty lines (without the TACACS+ authorization) create an access list that contains the IP addresses of the users that you want to grant access to these vty lines—these users are granted access to the **mirror-enable** command, and therefore, the packet mirroring feature.

This configuration grants access to the packet mirroring CLI commands to the users from the specified IP addresses. The packet mirroring commands remain hidden for all other users.

CLI-Based Packet Mirroring Sequence of Events

Figure 19 shows the sequence of events that take place during CLI-based mirroring. The tables after the figure describe the events indicated by the numbers and letters in the figure. Table 39 on page 199 describes the configuration process; Table 40 on page 200 describes the flow of traffic during a mirroring operation that is initiated when the user logs on; and Table 41 on page 200 describes the flow of traffic when mirroring a user who is already logged in or when mirroring a static interface.

Figure 19: CLI-Based Packet Mirroring



To create a CLI-based packet mirroring environment, you must complete the processes listed in Table 39.

Table 39: Setting Up the CLI-Based Packet Mirroring Environment

Process	Description
A	The authorized individual requests packet mirroring of a user's or interface's traffic and configures the analyzer device to receive mirrored traffic.
B	An individual who is authorized to use the packet mirroring CLI commands configures the packet mirroring environment, including the secure policy, analyzer interface connection to the analyzer device, and the interface or trigger information.

Table 40 indicates the sequence of steps for a packet mirroring operation that takes place when a user starts a new session.

Table 40: CLI-Based User-Specific Mirroring During Session Start

Step	Description
1	The user logs on to an E-series router, requesting authentication by AAA.
2	AAA authenticates the user, and the router starts mirroring the user's traffic.
3	The router sends the user's original traffic to the intended destination.
4	The router sends the mirrored traffic to the analyzer device.
5	The analyzer device provides information to the requesting individual.

Table 41 indicates the sequence of steps for a packet mirroring operation that is configured for an interface or for a user who is already logged in.

Table 41: CLI-Based Mirroring of Currently Running Session

Step	Description
1	For user-specific mirroring, the user logs on to the E-series router; no mirroring action is configured.
2	■ CLI-based packet mirroring is configured and enabled on the router. ■ For interface-specific mirroring, the router starts mirroring all traffic for the interface. ■ For user-specific mirroring, AAA verifies that the mirrored user is already logged in, then starts mirroring all subsequent traffic to or from the user.
3	The router sends the original traffic to its intended destination.
4	The router sends mirrored traffic to the analyzer device.
5	The analyzer device provides information for the requesting individual.

Configuring CLI-Based Mirroring

To configure the CLI-based packet mirroring environment, you must coordinate the mirroring operations of two devices in the network: the E-series router and the analyzer device. The configuration of the analyzer device is mentioned in this section for reference only. The actual configuration procedures depend on the policies and guidelines established by the responsible organizations.

The **ip policy** command is visible only to authorized users—the **mirror-enable** command must be enabled prior to using this command. If you enter the **ip policy** command with the **secure-input** or **secure-output** keyword and the policy list does not exist, the router creates a policy list with a default mirror rule that disables mirroring. If you attach this policy list to an interface, there is no packet mirroring. When you use this command to create a secure policy list, statistics-related keywords are not supported.

The **secure ip classifier-list** command creates or modifies a secure IP classifier control list, which can then be included in a secure policy list.

NOTE: Do not use the asterisk (*) for the name of a classifier list. The asterisk is used as a wildcard for the **classifier-group** command.

Except for the following considerations, secure IP classifier lists are created and function the same as standard IP classifier lists—see the *Chapter 2, Creating Classifier Control Lists for Policies* for information:

- This command is visible only to authorized users—the **mirror-enable** command must be enabled prior to using this command.
- Secure IP classifier lists are the only type of classifier lists allowed in secure policy lists
- Secure IP classifier lists cannot be used in non-secure policy lists.

The **secure ip policy-list** and **secure l2tp policy-list** commands create or modify a secure IP or L2TP policy list. These commands are visible only to authorized users—the **mirror-enable** command must be enabled prior to using this command. These commands enter Policy List Configuration mode, enabling you to specify the parameters of the secure policy list. If you enter Policy List Configuration mode and then type **exit** without specifying any parameters, the router creates a policy list with a mirror disable rule. Attaching this policy list to an interface results in no packet mirroring. Secure IP classifier lists are the only type of classifier lists allowed in secure IP policy lists. Secure L2TP policies do not support classification. Therefore, the only classifier group you can use for secure L2TP policies is **classifier-group *****. You cannot delete a secure policy list that is currently attached to an interface.

Related Topics

- **classifier-group** command
- **ip analyzer** command
- **ip mirror** command
- **ip policy** command
- **mirror** command
- **mirror analyzer-ip-address** command
- **mirror disable** command
- **mirror-enable** command
- **secure ip classifier-list** command
- **secure ip policy-list** command
- **secure l2tp policy-list** command

Configuring the Analyzer Device

The analyzer device must be configured to receive the mirrored traffic from the E-series router's analyzer interface. You can use the **default** keyword to configure an interface as the virtual router's default analyzer interface; it is then used when an analyzer interface is not explicitly specified in the **ip mirror** command. You cannot configure multiaccess interfaces, such as IP over Ethernet, as default analyzer interfaces.

You can configure any type of IP interface on the E-series router as an analyzer interface, except for special interfaces such as SRP interfaces, null interfaces, and loopback interfaces. An interface cannot be both an analyzer interface and a mirrored interface at the same time. A single analyzer interface can serve multiple mirrored sessions.

The receive side of an analyzer interface is disabled; all traffic attempting to access the router through an analyzer interface is dropped. Analyzer interfaces drop all nonmirrored traffic.

Policies are not supported on analyzer interfaces. When you configure an analyzer interface, existing policies are disabled, and no new policies are accepted.

Configuring the E-series Router

To configure the router to support CLI-based packet mirroring:

1. Configure the analyzer interface, the route to the analyzer device, and any static ARP entries.
2. Allow authorized users to have access to the **mirror-enable** command. The users can then make the packet mirroring CLI commands visible and perform the following steps.
3. Configure the secure policy that forwards the mirrored traffic to the analyzer device.
4. (Optional) For increased security, create an IPSec tunnel between the analyzer interface and the analyzer device.
5. For interface-specific mirroring, attach the secure policy to the interface.
6. For user-specific mirroring, configure the trigger that identifies the user.

Configuring CLI-Based Interface-Specific Mirroring

This example shows the configuration of a CLI-based packet mirroring session for a particular static IP interface. The configuration results in all traffic through the interface being replicated and the replicated traffic then sent through an IPSec tunnel to the analyzer device.

1. Enable the visibility and use of the packet mirroring CLI commands.

   host1#**mirror-enable**

2. Configure the analyzer interface and a route to reach the analyzer device at 192.168.125.29.

NOTE: If the analyzer interface is Ethernet-based, you must configure a static ARP entry for the analyzer device.

```
host1(config)#virtual-router vr1
host1:vr1(config)#interface tunnel ipsec:Diag transport-virtual-router default
host1:vr1(config-if)#ip analyzer
host1:vr1(config-if)#exit
host1:vr1(config)#ip route 192.168.125.29 255.255.255.255 tunnel ipsec:Diag
```

3. Configure the secure IP policy that forwards the mirrored traffic to the analyzer device at 192.168.125.29.

   In this example, the configured mirror rule does not include the **analyzer-udp-port** keyword. Therefore, the rule sets the mirror header to **disable**, which means that the mirror header is not prepended to the mirrored packets. See *Understanding the Prepended Header During a Packet Mirroring Session* on page 216 for information about the prepended mirror header. The **classifier-group** command uses a previously configured classifier list, secClassA.

```
host1:vr1(config)#secure ip policy-list secureIpPolicy1
host1:vr1(config-policy-list)#classifier-group secClassA
host1:vr1(config-policy-list-classifier-group)#mirror analyzer-ip-address
192.168.125.29 analyzer-virtual-router vr1
```

4. Attach the secure policy to the interfaces whose traffic you want to mirror. This example mirrors input traffic at interface ATM 5/0.1 and output traffic at interface ATM 5/0.2.

```
host1:vr1(config)#interface atm 5/0.1
host1:vr1(config-if)#ip policy secure-input secureIpPolicy1
```

```
host1:vr1(config)#interface atm 5/0.2
host1:vr1(config-if)#ip policy secure-output secureIpPolicy1
```

5. Verify the secure policy configuration.

```
host1#show secure policy-list name secureIpPolicy1

                                Policy Table
                                ------ -----
Secure IP Policy secureIpPolicy1
 Administrative state: enable
 Reference count:      2
 Classifier control list: secClassA
  mirror analyzer-ip-address 192.168.125.29 analyzer-virtual-router vr1

 Referenced by interface(s):
  ATM5/0.1  secure-input policy, virtual-router vr1
  ATM5/0.2  secure-output policy, virtual-router vr1
```

Configuring CLI-Based User-Specific Mirroring

In user-specific packet mirroring, you use triggers to identify the user whose traffic you want to mirror and to start the mirroring session. The triggers are similar to the RADIUS attributes used in RADIUS-based mirroring. However, for CLI-based mirroring, AAA can use any supported authentication method, including RADIUS.

NOTE: An E-series router supports a maximum of 100 mirror trigger rules.

You can use the following triggers to identify users:

- Username (virtual router specific)
- IP address (virtual router specific)
- Calling station ID
- Account session ID

The following considerations apply to trigger rules:

- A new trigger rule is not applied to matching connected subscribers if any of the subscribers is mirrored by another rule.
- When you remove a rule, mirroring is terminated for all affected subscribers.
- CLI-initiated mirroring per account session ID creates a rule that continues to exist after the subscriber logs out.
- RADIUS CoA messages do not create rules and affect only currently connected subscribers.

This example shows the configuration of a CLI-based packet mirroring session for an L2TP user. The configuration uses the username as the trigger to identify the user and start the mirroring session. The mirroring session replicates all traffic associated with the user, and then sends the replicated traffic through an IPSec tunnel to the analyzer device.

1. Enable the visibility and use of the packet mirroring CLI commands.

   host1#**mirror-enable**

2. Create the analyzer interface and the route to the analyzer device at address 192.168.99.2.

   host1(config)# **interface tunnel ipsec:mirror3 transport-virtual-router default**
   host1(config-if)#**ip analyzer**
   host1(config-if)#**exit**
   host1(config)#**ip route 192.168.99.2 255.255.255.255 tunnel ipsec:mirror3**

3. Configure the secure L2TP policy that forwards the mirrored traffic to the analyzer device at 192.168.99.2, port 6500. The **classifier-group** command uses the default classifier list, which is indicated by the asterisk character (*).

```
hosts1(config)#secure l2tp policy-list l2tp_toMirrorHQ
host1(config-policy-list)#classifier-group *
host1(config-policy-list-classifier-group)#mirror analyzer-ip-address 192.168.99.2
analyzer-virtual-router default analyzer-udp-port 6500 mirror-identifier 1
session-identifier 1
```

4. Configure packet mirroring for the subscriber identified by username jwbooth@isptheatre.com and associate the secure policy with the user.

```
host1(config)#virtual-router lac
host1:lac(config)#mirror username jwbooth@isptheatre.com l2tp
secure-policy-list l2tp_toMirrorHQ
```

Now, when subscriber jwbooth@isptheatre.com logs in, the packet mirroring session starts and the subscriber's replicated traffic is sent through the secure IPSec tunnel to the remote analyzer device.

5. Verify the packet mirroring configuration.

```
host1#show mirror subscribers

Subscriber ID                Subscriber ID       Secure Policy  Secure Policy List  Sessions
                             Method              Type                               Mirrored
-----------------            ------------------  -------------  ------------------  --------
lac:jwbooth@isptheatre.com   username            l2tp           l2tp_toMirrorHQ     1
```

6. Verify the configuration of the secure L2TP policy.

```
host1#show secure policy-list name l2tp_toMirrorHQ

                                  Policy Table
                                  ------ -----
Secure L2TP Policy l2tp_toMirrorHQ
 Administrative state: enable
 Reference count:      2
 Classifier control list: *
  mirror analyzer-ip-address 192.168.99.2 analyzer-virtual-router default
analyzer-udp-port 6500 mirror-id 1 session-id 1

 Referenced by interface(s):
  TUNNEL l2tp:5/1/5  secure-input policy
  TUNNEL l2tp:5/1/5  secure-output policy
```

Chapter 12

Configuring RADIUS-Based Mirroring

Packet mirroring enables you to send a copy of a packet to an external host for analysis. Packet mirroring has many uses, including traffic debugging and troubleshooting user networking problems.

This chapter contains the following sections:

RADIUS-Based Mirroring Overview

RADIUS-based packet mirroring enables you to mirror traffic related to a specific user, without regard to how often the user logs on or off, or which E-series router or interface the user uses. RADIUS-based mirroring is particularly appropriate for large networks, because you can use a single RADIUS server to provision mirroring on multiple E-series routers in a service provider's network. RADIUS-based mirroring is useful when debugging network problems related to mobile users, who do not always log on to a particular router.

You configure RADIUS-based mirroring independent of the actual mirroring session—you can configure the mirroring parameters at any time. RADIUS-based mirroring uses RADIUS and VSAs, rather than CLI commands, to specify the user whose traffic is to be mirrored. The VSAs specify attributes that are carried in Access-Accept messages and change-of-authorization messages from the RADIUS dynamic-request server to the E-series router.

NOTE: You cannot use RADIUS-initiated packet mirroring to mirror static interfaces, which might not be authenticated through RADIUS. To mirror static interfaces, you must use CLI-based mirroring.

NOTE: RADIUS-based packet mirroring is not supported on LAC L2TP sessions if the LAC uses domain maps to create tunnels or if authentication is disabled for both LAC and PPP termination.

RADIUS Attributes Used for Packet Mirroring

Table 42 lists the packet mirroring triggers. The triggers are RADIUS attributes that identify a user whose traffic is to be mirrored. A packet mirroring session starts when the router receives a RADIUS packet that contains mirroring attribute and then applies the mirroring configuration to the appropriate interface. For example, packet mirroring starts when a logon request occurs that contains a specified User-Name attribute.

The triggers also enable RADIUS-initiated mirroring to start when the user is already logged in.

Table 42: RADIUS Attributes Used as Packet Mirroring Triggers

Standard Number	Attribute Name
[1]	User-Name
[8]	Framed-IP-Address
[26-1]	Virtual-Router
[31]	Calling-Station-ID
[44]	Acct-Session-ID
[87]	Nas-Port-ID

You add the trigger to the RADIUS record of the user whose traffic will be mirrored. In addition, you must include the RADIUS VSAs listed in Table 43 in the mirrored user's RADIUS record.

NOTE: For IP mirroring, you must include both VSA 59 and 61 or neither. If you use only one of these two VSAs, the configuration fails.

Table 43: RADIUS-Based Mirroring Attributes

Standard Number	Attribute Name	Setting
[26-58]	LI-Action	0 = disable mirroring 1 = enable mirroring 2 = no action
[26-59]	Med-Dev-Handle	String (not null-terminated)
[26-60]	Med-IP-Address	IP address of analyzer device
[26-61]	Med-Port-Number	UDP port number of monitoring application in analyzer device

A Mirror-Action setting of 2 specifies that the router does not perform any packet mirroring–related configuration. This setting can provide additional security by confusing unauthorized users who attempt to access packet mirroring communication between the router and the RADIUS server.

RADIUS-Based Packet Mirroring Dynamically Created Secure Policies

RADIUS-based packet mirroring uses dynamically created secure policies, which are based on the RADIUS VSAs that an authorized RADIUS administrator creates. A policy is created when the packet mirroring action is initiated at the RADIUS server, and then applied to the interface that is dynamically created for the user. When the mirroring operation is disabled, the secure policy is deleted.

The E-series router creates a name for the dynamically created policies—the name consists of the string spl followed by a hexadecimal integer, such as spl_88000008. The name is displayed by the **show secure policy-list** command.

RADIUS-Based Packet Mirroring MLPPP Sessions

When you use RADIUS-based packet mirroring on MLPPP traffic, RADIUS authentication and authorization is performed on the individual links. The mirroring-related VSAs are returned with the RADIUS response. For user-initiated mirroring, which starts when the user logs on, a RADIUS response is returned for each successful authentication/authorization. For RADIUS-initiated mirroring of a user who is already logged in, a single RADIUS request is sent for each link.

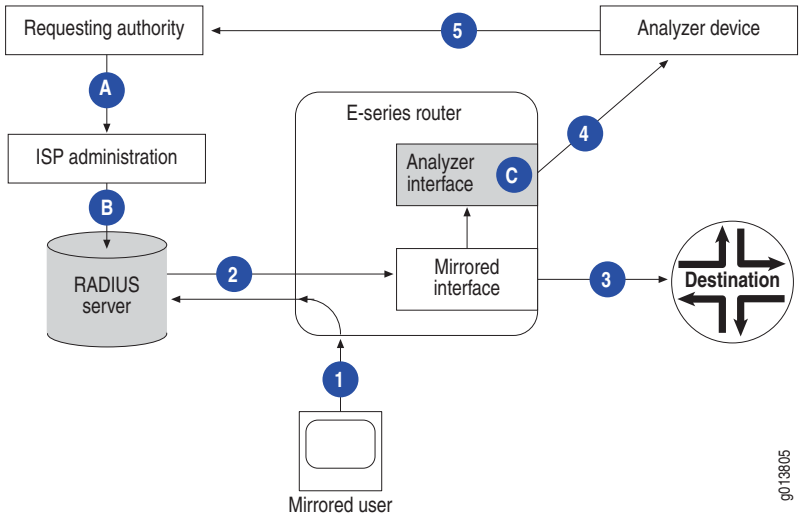
- If you are mirroring an L2TP session, the packet mirroring operation is enabled or disabled on a single link that is uniquely identified by the trigger you use (the RADIUS attributes for Acct-Session-ID or User-Name). For tunneled MLPPP, the individual links in the MLPPP bundle are mirrored separately. The packet mirroring configuration fails if you use the Acct-Multi-Session-ID attribute (RADIUS attribute 50) for the configuration.

- If you are mirroring an IP session, the packet mirroring operation is enabled or disabled on the MLPPP bundle as a whole. We recommend that you use the Account-Session-ID RADIUS attribute rather than the User-Name attribute as the trigger. Using the Account-Session-ID attribute is more efficient because the JUNOSe software creates one secure policy that packet mirroring uses for all links in the MLPPP bundle. If you use the User-Name attribute, a secure policy is created for the first link, then removed and re-created for every other link.

RADIUS-Based Mirroring Sequence of Events

Figure 20 on page 210 shows the sequence of events that take place during RADIUS-based mirroring. The tables after the figure describe the events indicated by the numbers and letters in the figure. Table 44 on page 210 describes the configuration process; Table 45 on page 211 describes the flow of traffic during a mirroring operation that is initiated when the user logs on; and Table 46 on page 211 describes the flow of traffic when mirroring a user who is already logged in.

Figure 20: RADIUS-Based Packet Mirroring



To create a RADIUS-based packet mirroring environment, you must complete the processes listed in Table 44.

Table 44: Setting Up the RADIUS-Based Packet Mirroring Environment

Process	Description
A	The authorized individual requests packet mirroring of the user's traffic and configures the analyzer device to receive mirrored traffic.
B	The ISP administration configures VSAs in the user's RADIUS record.
C	The E-series router administrator configures RADIUS server information and the analyzer interface connection to the analyzer device.

Table 45 indicates the sequence of steps for a packet mirroring operation that takes place when a user starts a new session.

Table 45: RADIUS-Based Mirroring During Session Start

Step	Description
1	The user logs on to an E-series router, requesting authentication by the RADIUS server. A trigger in the logon request starts the packet mirroring session.
2	■ The RADIUS server authenticates the user and sends packet mirroring VSAs and any other configured VSAs to the router. ■ The router creates a secure policy based on the VSAs and starts mirroring the user's traffic.
3	The router sends the user's original traffic to its intended destination.
4	The router sends the mirrored traffic to analyzer device.
5	The analyzer device provides information for the requesting individual.

Table 46 indicates the sequence of steps for a packet mirroring operation that is configured for a currently running session.

Table 46: RADIUS-Based Mirroring of Currently Running Session

Step	Description
1	The user logs on to the E-series router; no mirroring action is configured.
2	■ Packet mirroring is enabled on the RADIUS server. ■ The RADIUS server sends change-of-authorization messages containing packet mirroring VSAs to the router. ■ The router creates a secure policy based on the VSAs and starts mirroring the user's traffic.
3	The router sends the user's original traffic to its intended destination.
4	The router sends mirrored traffic to the analyzer device.
5	The analyzer device provides information for the requesting individual.

Configuring RADIUS-Based Mirroring

To configure the RADIUS-based packet mirroring environment, you must coordinate the mirroring operations of three devices in the network: the RADIUS server, the E-series router, and the analyzer device. The configuration of the RADIUS server and the analyzer device is described in this section for reference only. The actual configuration procedures depend on the policies and guidelines established by the responsible organizations.

Configuring the RADIUS Server

Table 43 on page 209 lists the VSAs that are included for both types of RADIUS-based mirroring—user-initiated (when the user logs on to start a new session), and RADIUS-initiated (when the user is already logged in).

Disabling RADIUS-Based Mirroring

To disable mirroring, you include the RADIUS attribute (for example, Acct-Session-ID) and set the Mirror-Action attribute to 0 in the mirrored user's RADIUS record.

You can also use the **mirror disable** CLI commands to disable RADIUS-based mirroring. You must use the version of the **mirror disable** command that corresponds to the RADIUS attribute that was used to identify the user. For example, if you used the RADIUS Calling-Station-ID attribute to create the mirroring session, you must use the **mirror disable calling-station-id** command to disable the session.

NOTE: All RADIUS-based mirroring sessions that start when a user logs on are considered to use the Acct-Session-ID attribute. Therefore, you must use the **mirror disable acct-session-id** command to disable these sessions. For RADIUS-based sessions of a user that is already logged in, you use the **mirror disable** command with the same keyword you used to configure the session.

Configuring the Analyzer Device

The analyzer device must be configured to receive the mirrored traffic from the E-series router's analyzer interface. The analyzer interface directs mirrored traffic to the specified analyzer device for analysis. You can configure the interface as the virtual router's default analyzer interface. You cannot configure multiaccess interfaces, such as IP over Ethernet, as default analyzer interfaces.

When mirroring an IP interface, the analyzer interface must reside in the same virtual router as the mirrored interface. When mirroring an L2TP interface, the analyzer interface must reside in the default virtual router.

NOTE: You must configure a static route to reach the analyzer device through the analyzer interface. If the analyzer interface is an IP over Ethernet interface, you must also configure a static Address Resolution Protocol (ARP) entry to reach the analyzer device.

You can configure any type of IP interface on the E-series router as an analyzer interface, except for special interfaces such as SRP interfaces, null interfaces, and loopback interfaces. An interface cannot be both an analyzer interface and a mirrored interface at the same time. A single analyzer interface can support multiple mirrored interfaces.The receive side of the analyzer interface is disabled. All traffic attempting to access the router through an analyzer interface is dropped.Analyzer interfaces drop all nonmirrored traffic. Policies are not supported. When you configure an analyzer interface, existing policies are disabled, and no new policies are accepted.

Related Topics

- **authorization change** command
- **ip analyzer** command
- **key** command

- **mirror disable** command
- **radius dynamic-request server** command
- **udp-port** command

Configuring Router to Start Mirroring When User Logs On

To configure the router to support RADIUS-based mirroring that starts when the user logs on:

1. Configure RADIUS server authentication information in the router. See *JUNOSe Broadband Access Configuration Guide, Chapter 1, Configuring Remote Access* for information.
2. Ensure that the analyzer interface is configured to send the mirrored traffic to the analyzer device.
3. (Optional) For increased security, create an IPSec tunnel between the analyzer interface and the analyzer device.

Configuring Router to Mirror Users Already Logged On

To configure the router to support RADIUS-initiated mirroring when the user is already logged in:

1. Specify the RADIUS server that sends change-of-authorization messages to the router.
2. Specify the UDP port used to communicate with the RADIUS server.
3. Configure the key used when communicating with the RADIUS server.
4. Enable the router to receive change-of-authorization messages from the RADIUS server.
5. Ensure that the analyzer interface is configured to send the mirrored traffic to the analyzer device.
6. (Optional) For increased security, create an IPSec tunnel between the analyzer interface and the analyzer device.

Configuring RADIUS-Initiated Mirroring When Users Are Logged On

When a mirroring operation is initiated for a user who is already logged on, the RADIUS server uses change-of-authorization messages and passes the required RADIUS attributes and the identifier of the currently running session to the E-series router. The router uses this information to create the secure policy and attaches it to the interface that is created for the user. The E-series router must be configured to accept change-of-authorization messages from the RADIUS server.

1. Specify the RADIUS dynamic-request server, and enter RADIUS configuration mode.

   host1(config)#**radius dynamic-request server 192.168.11.0**

2. Specify the UDP port used to communicate with the RADIUS server.

   host1(config-radius)#**udp-port 3799**

3. Create the key used to communicate with the RADIUS server.

   host1(config-radius)#**key mysecret**

4. Configure the router to receive change-of-authorization messages from the RADIUS server.

   host1(config-radius)#**authorization change**
   host1(config-radius)#**exit**
   host1(config)#**exit**

5. Verify your RADIUS-initiated mirroring configuration.

```
host1#show radius dynamic-request servers

               RADIUS Request Configuration
               ----------------------------
                                    Change
                Udp                   Of
 IP Address     Port   Disconnect   Authorization   Secret
-------------   ----   ----------   -------------   ------
 10.10.3.4      3799   enabled      enabled         mysecret
```

6. Create the analyzer interface.

   host1(config)#**interface fastEthernet 4/0**
   host1(config-if)#**ip analyzer**

Chapter 13

Managing Packet Mirroring

Packet mirroring enables you to send a copy of a packet to an external host for analysis. Packet mirroring has many uses, including traffic debugging and troubleshooting user networking problems.

This chapter contains the following topics:

Avoiding Conflicts Between CLI-Based and RADIUS-Based Packet Mirroring Configurations

The JUNOSe software gives you a great deal of flexibility in creating your packet mirroring environment by supporting both the CLI-based and the RADIUS-based configuration methods. However, a conflict might occur when you use both methods. For example, you might have both a CLI-based session and a RADIUS-based session for the same subscriber, each session using a unique secure policy list.

To avoid potential conflicts when both CLI-based and RADIUS-based configurations exist for a subscriber, the JUNOSe software uses the following rules to determine which configuration to use:

- When a user logs in—The RADIUS-based configuration is always used
- When the user is already logged in—The new configuration always replaces the existing configuration, regardless of creation method.

Understanding the Prepended Header During a Packet Mirroring Session

During a packet mirroring session, the router prepends a special UDP/IP header to each mirrored packet that is sent to the analyzer interface. This prepended header is created by the policy-mirroring action, and is used for demultiplexing at the analyzer to sort through the multiple mirrored streams that arrive from different sources.

All mirrored L2TP session packets are prepended with UDP/IP header. However, for IP traffic mirroring, the prepend header is optional; the header is added if the mirroring-related VSAs (VSAs 59 and 61) are included in the RADIUS message. For CLI-based mirroring, the **analyzer-udp-port** keyword of the **mirror analyzer-ip-address** command creates the same information contained in the two VSAs. If you do not include the VSAs or the **analyzer-udp-port** keyword, an IP mirroring action is indicated, and the prepend header is not used.

NOTE: For IP mirroring, both VSA 26-59 and 26-61 or neither must be included. If only one of the VSAs is used, the configuration fails.

Figure 21 shows the structure of the prepended header. The values in parentheses indicate the fixed value for individual fields. For fields that do not have a fixed value listed, the value is dynamically created for each mirrored packet. Table 47 on page 217 lists the fields in the prepended header and indicates the values and field length.

Figure 21: Prepended Header

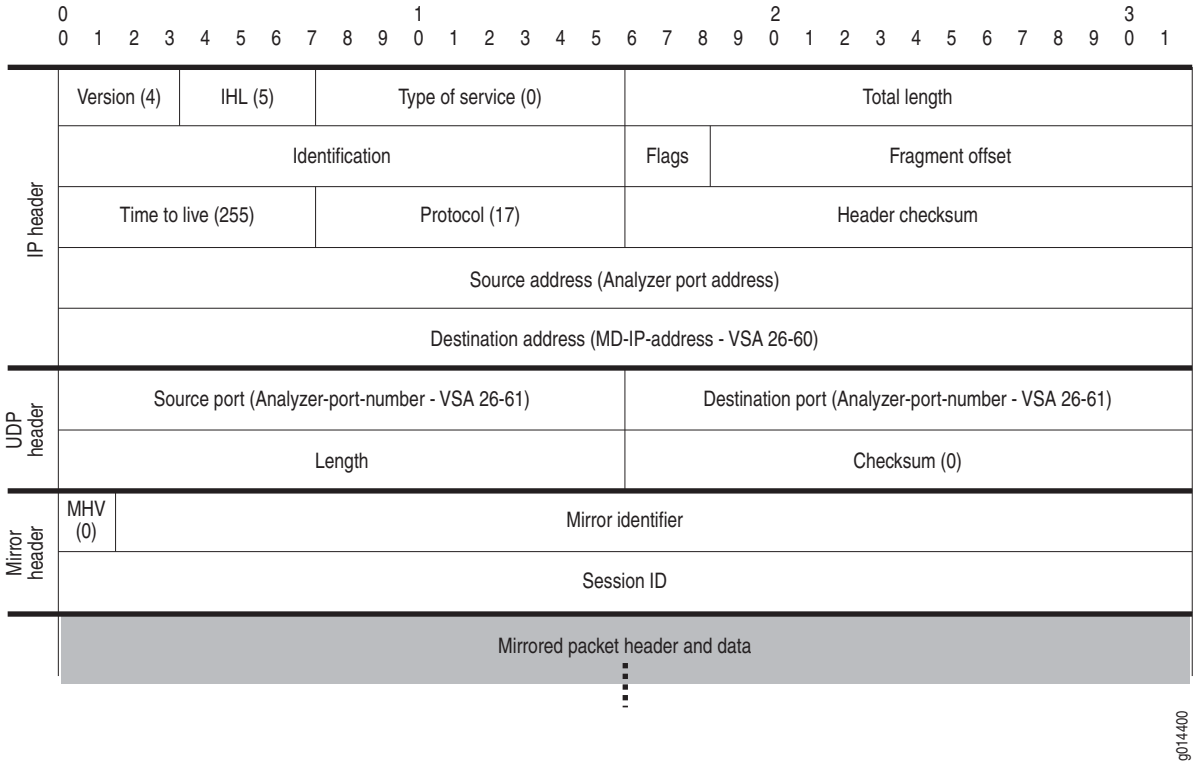


Table 47: Prepended Header Field Descriptions

Field	Value	Length (Bits)
IP Header		
Version	4	4
IHL	5	4
Type of Service	0	8
Total Length	Dynamically computed	16
Identification	Dynamically computed	16
Flags	Dynamically computed	3
Fragment Offset	Dynamically computed	13
Time to Live	255	8
Protocol	17	8
Header Checksum	Dynamically computed	16
Source Address	Analyzer interface IP address	32
Destination Address	VSA 26-60	32
UDP Header		
Source Port	VSA 26-61	16
Destination Port	VSA 26-61	16
Length	Dynamically computed	16
Checksum	0	16

Table 47: Prepended Header Field Descriptions (continued)

Field	Value	Length (Bits)
Mirror Header		
MHV (mirror header value)	0	2
Mirror Identifier	See *Format of the Mirror Header Attributes* on page 218 for details	30
Session-ID	See *Format of the Mirror Header Attributes* on page 218 for details	32

Format of the Mirror Header Attributes

The mirror header values are determined by the value that you configure in VSA 26-59. VSA 26-59 is declared as a hexadecimal string that can be either 8 bytes or 4 bytes long. The 8-byte format enables you to further specify the value that is used for the Session-ID field. If you use the 4-byte format, the router automatically determines the Session-ID field. The value in the 2-bit version field specifies the format that is used—0 indicates the 8-byte format, and 1 indicates the 4-byte format.

8-Byte Format

The 8-byte format of VSA 26-59 enables you to manually specify the Session-ID value in addition to the Mirror Identifier value. To use the 8-byte format, you configure the first two most significant bits of the first word of the VSA to a value of 0, which indicates two words in the VSA. The remaining 30 bits of the first word form the Mirror Identifier value, and the second word is the Session-ID field. You cannot change the order of these two words.

For example, a value of 0000030000000090 in VSA 26-59 configures the following fields in the mirror header, as shown in Figure 22:

- MHV = 0
- Mirror Identifier = 0x300
- Session-ID = 0x90

Figure 22: 8-Byte Format of VSA 26-59

4-Byte Format

To use the 4-byte format of VSA 26-59, you configure the first two most significant bits of the VSA to a value of 1, which indicates a single word in the VSA. The remaining 30 bits of the word form the Mirror Identifier value. The router then creates the Session-ID value based on the least significant 32 bits of the Acct-Session-ID (RADIUS attribute 44).

For example, a value of 40000010 for VSA 26-59 configures the following fields in the mirror header, as shown in Figure 23:

- MHV = 1
- Mirror Identifier = 0x10

Figure 23: 4-Byte Format of VSA 26-59

Resolving and Tracking the Analyzer Device's Address

During the packet mirroring configuration process, you specify the IP address of the analyzer device to which the mirrored traffic is sent. For CLI-based packet mirroring, you use the **mirror analyzer-ip-address** command to specify the IP address. For RADIUS-based packet mirroring, the RADIUS attribute Med-IP-Address [26-60] is the address of the analyzer device.

After configuration is complete, the router performs a route lookup to resolve the analyzer device's address and to ensure that traffic can be forwarded to the analyzer device for analysis. However, the analyzer device is considered unreachable if the router's analyzer interface is not in analyzer mode, is not yet created, or if the routes to the analyzer device are absent

If the analyzer device is unreachable, then the mirror action in the secure policy is disabled, and no packets are mirrored. The **show secure policy-list** command output indicates that the mirror action is disabled and the analyzer device is unreachable.

The router tracks the analyzer device's IP address for any route changes within the router. This tracking ability provides a degree of failure recovery by enabling you to configure multiple analyzer interfaces to serve as redundant ports to reach the analyzer device.

Using Multiple Triggers for CLI-Based Packet Mirroring

When you configure CLI-based packet mirroring, you can create multiple mirroring rules for a particular subscriber. For example. you might create two rules; one that uses IP address as the trigger that identifies the user and a second with the subscriber's username as the trigger. You can also configure RADIUS-based mirroring to use multiple methods to identify subscribers.

To avoid conflicts between multiple mirroring rules, both CLI-based and RADIUS based mirroring operations assign a precedence to the subscriber identification triggers. When multiple rules are configured for the same subscriber, the rule with the highest precedence is used to identify the subscriber.

The following list indicates the order of precedence for the subscriber identification triggers, with the acct-session-id having the highest precedence.

1. acct-session-id
2. calling-station-id
3. ip-address (virtual router specific)
4. nas-port-id
5. username (virtual router specific)

For example, if you create the following three rules for a subscriber, the packet mirroring session uses the rule with the acct-session-id to identify the subscriber. When there are multiple rules, if the selected rule fails, the router denies the packet mirroring request and does not attempt to use the other rules.

host1(config)#**mirror acct-session-id atm 2/1.2:0.42:0001048579 ip secure-policy-list securePolicyIp10**
host1(config)#**mirror ip-address 192.168.105.25 ip secure-policy-list securePolicyIp4**
host1(config)#**mirror username jwbooth@isptheatre.com ip secure-policy-list securePolicyIp15**

If the packet mirroring request is a RADIUS-initiated session (a RADIUS-based packet mirroring session for a subscriber who is already logged in), the router verifies the validity of all of the mirroring rules related to the particular subscriber. If any of the rules fail (for example, the identification fields do not match), the packet mirroring request is denied.

The calling-station-id trigger is externally visible only for tunneled users (if there are no RADIUS overrides). If a case-sensitive user name does not match a subscriber's name or if the dynamic IP interface UID does not exist, the subscriber is disregarded.

Optimizing Packet Mirroring Performance

Packet mirroring operations require some system resources. As a general rule, to avoid performance degradation, limit the amount of mirrored traffic to a maximum of 5 percent of the E-series router's total traffic.

For many packet mirroring environments, using the 5-percent guideline is sufficient. However, if you want to more closely manage packet mirroring's use of your router's resources, this section provides guidelines and equations to help you determine your packet mirroring requirements.

The guidelines for packet mirroring requirements use the following assumptions for a specific line module:

A = Total input traffic at the line module

B = Total output traffic at the line module

X = Amount of traffic mirrored at input in the line module

Y = Amount of traffic mirrored at output in the line module

Determine Traffic Loads

Using the previous assumptions, you can determine traffic loads for a given line module:

A =	Load at ingress side of the line module
(B + X) =	Load at egress side of the line module
(A + 2X + Y) =	Load at ingress to fabric from the line module

Establish Resource Guidelines

Next, using the traffic loads that you determined for the line module, you can establish guidelines for the amount of packet mirroring traffic for your router.

If you exceed these guidelines, regular (non-packet mirroring) packets from all subscribers, including nonmirrored subscribers, will be dropped. If the fabric bandwidth is not exceeded, then the performance penalties are contained within the slot where the packet mirroring activity occurs. However, if the fabric bandwidth is exceeded, traffic from other line modules might also be dropped.

- (A + 2X + Y) must be less than the maximum fabric bandwidth supported from this line module.
- (2X + Y) must be less than 100Mbps (the enforced queue limit).

  The 100 Mbps limit does not apply to the following line modules:

  - GE-2 line module (ERX-310 router and ERX-1440 router)
  - GE-HDE line module (ERX-310 router and ERX-1440 router)
  - OC48 Frame APS I/O module (ERX-1440 router only)
  - ES2 4G LM (E120 router and E320 router)
- (B + X) must be less than the maximum supported egress bandwidth.
- The number of mirrored interfaces per line module must be less than 1023 (the configuration enforced for secure policy attachments).
- The number of interfaces mirrored per chassis must be less than 2400 (the configuration enforced for secure policy attachments).

NOTE: Packet mirroring can also affect the forwarding controller's packet handling performance.

Logging Packet Mirroring Information

The JUNOSe software's packet mirroring feature provides two secure methods of capturing and displaying packet mirroring-related information. Both methods ensure security by requiring the **mirror-enable** command to be enabled.

- Secure logging—Captures packet mirroring information to a local secure log on the router.
- SNMP secure packet mirroring traps—Captures and reports packet mirroring information to an external device; you can then use the privileged **show mirror trap** and **show snmp traps** CLI commands to view secure trap configuration information.

  SNMP agent also implements a secure audit logging facility for the debugging of packet mirroring traps and packet Mirror-MIB accesses. When secure audit logging is enabled, SNMP agent logs reported mirror traps and packet Mirror-MIB get/set operations to local volatile memory on the router.

By default, the JUNOSe software captures packet mirroring-related activity to a secure local mirror log. No action is required on your part to enable or disable the logging process; however, only authorized users can access the secure log.

The secure logging feature includes the **clear mirror log** and **show mirror log** commands. The **mirror-enable** command must be enabled to make the commands visible in the CLI.

Related Topics

- **clear mirror log** command
- **show mirror log** command

Using SNMP Secure Packet Mirroring Traps

SNMP secure packet mirroring traps enable you to capture and report packet mirroring information to an external device; you can then view the secure information on the remote device. The secure packet mirroring traps feature is an extension of the router's standard SNMP implementation, and is only available to SNMPv3 users who are authorized to use packet mirroring.

You can also log mirror traps to local volatile memory for debugging purposes by enabling the SNMP secure log feature. See *Capturing SNMP Secure Audit Logs* on page 226 for details of secure audit logging. Normal console and syslog audit logs for packet mirroring traps and packet Mirror-MIB accesses are suppressed due to security concerns.

NOTE: The contents of secure logs are not preserved across a reboot.

The **mirror-enable** command must be enabled to make packet mirroring-related commands, command options, and **show** command output visible.

NOTE: You must use the CLI to configure the secure packet mirroring trap category to allow transmission of secure packet mirroring traps through the router—you cannot use SNMP to configure the secure packet mirroring trap category. However, after you have configured the secure packet mirroring trap category using the CLI, you can then use SNMP (juniPacketMirrorMIB.mi2) to enable and disable secure packet mirroring traps.

Related Topics

- See *JUNOSe System Basics Configuration Guide, Chapter 4, Configuring SNMP* for information about JUNOSe software SNMP support.
- **mirror trap-enable** command
- **snmp-server clear secure-log** command
- **snmp-server enable traps** command
- **snmp-server host** command
- **snmp-server secure-log** command
- **show mirror trap** command
- **show snmp secure-log** command

Table 48 indicates the events that trigger secure packet-mirroring traps and lists the information sent in the trap for each event.

Table 48: Packet-Mirroring SNMP Traps

Trap Information Sent	Event That Triggers the Trap			
	A secure policy failed during CoA-based or RADIUS-initiated packet mirroring	**A secure policy failed during CLI trigger or CLI-based packet mirroring**	**An interface with secure policies attached is deleted**	**An analyzer is unreachable**
Analyzer address	–	–	–	✔
Application name	✔	✔	–	–
Configuration source	✔	✔	✔	–
Date and time of event	–	✔	✔	✔
Error cause	✔	✔	–	–
Error string	✔	✔	–	–
Mirror ID	✔	–	✔	–
Mirroring direction	–	–	✔	–
Secure policy name	–	✔	✔	–

Table 48: Packet-Mirroring SNMP Traps (continued)

Trap Information Sent	Event That Triggers the Trap			
	A secure policy failed during CoA-based or RADIUS-initiated packet mirroring	A secure policy failed during CLI trigger or CLI-based packet mirroring	An interface with secure policies attached is deleted	An analyzer is unreachable
Secure policy UID	–	✔	✔	–
Session ID	✔	–	✔	–
Trigger event	✔	✔	✔	–
Trigger type	✔	✔	✔	–
Username	✔	–	–	–
Virtual router (0 for L2TP)	✔	✔	✔	✔

Additional Packet-Mirroring Traps for CALEA Compliance

You can use the packet-mirroring traps shown in Table 49 to help support compliance with the Communications Assistance for Law Enforcement Act (CALEA), which defines electronic surveillance guidelines for telecommunications companies. For example, a third-party vendor of mediation devices might receive packet mirroring traps from the router and convert the traps to messages that comply with CALEA, such as Lawfully Authorized Electronic Surveillance (LAES) for IP Network Access, American Nation Standard For Telecommunications messages. Individual traps might map to multiple LAES messages to provide additional compliance-related information.

Table 49: Packet-Mirroring Traps for CALEA Compliance

Trap	Description
juniPacketMirrorSessionStart	A grant has been issued to a mirrored subscriber.
juniPacketMirrorSessionEnd	A mirrored session has been terminated; includes the termination reason.
juniPacketMirrorInterfaceSessionActivated	A secure policy has been attached to an existing interface or to an existing session.
juniPacketMirrorInterfaceSessionDeactivated	A secure policy has been detached from an interface, not including interface or session termination.
juniPacketMirrorSessionReject	A deny has been issued because the potential mirrored user was not allowed on the network for some reason. However, the user would have been mirrored if access to the network had been allowed.
juniPacketMirrorSessionFailed	The user session was terminated before the secure policy was attached. For example, no resources were available to create the interface. The termination reason is included.

Packet Mirroring Trap Severity Levels

Table 50 lists the default severity levels for packet mirroring traps. See Table 23 in *JUNOSe System Basics Configuration Guide, Chapter 4, Configuring SNMP* for descriptions of the severity levels.

Table 50: Packet Mirroring Trap Severity Levels

Trap	Default Severity Level
juniPacketMirrorAnalyzerUnreachable	Warning
juniPacketMirrorCliTriggerBasedMirroringFailure	Error
juniPacketMirrorInterfaceDeleted	Notice
juniPacketMirrorInterfaceSessionActivated	Info
juniPacketMirrorInterfaceSessionDeactivated	Info
juniPacketMirrorRadiusBasedMirroringFailure	Error
juniPacketMirrorSessionEnd	Info
juniPacketMirrorSessionFailed	Info
juniPacketMirrorSessionStart	Info
juniPacketMirrorSessionReject	Info

Configuring SNMP Secure Packet Mirroring Traps

To configure SNMP secure traps support, perform the following tasks on your E-series router:

1. Enable packet mirroring support.
2. Configure the packet mirroring application to generate traps.
3. (Optional) Verify the packet mirroring trap configuration.
4. (Optional) Configure the SNMP server to support secure logs.
5. Configure the SNMP server to generate packet mirroring traps.
6. Configure the SNMPv3 user for whom packet mirroring traps are generated.
7. Configure the SNMP server to report packet mirroring traps to a remote host.
8. (Optional) Verify the SNMP server packet mirroring configuration.

The following example illustrates the procedure to configure SNMP secure packet mirroring traps support:

```
host1#mirror-enable
host1#configure terminal
host1(config)#mirror trap-enable
host1(config)#show mirror trap
Traps are enabled
host1(config)#snmp-server secure-log
host1(config)#snmp-server user fredMirrorUser group mirror authentication md5
fred-md5password privacy des fred-despassword
```

```
host1(config)#snmp-server enable traps packetMirror trapFilters notice
host1(config)#snmp-server host 192.168.57.103 version 3 fredMirrorUser
cliSecurityAlert packetMirror trapFilters notice
host1(config)#show snmp trap

Enabled Categories: CliSecurity, PacketMirror, Sonet
SNMP authentication failure trap is disabled
Trap Source: FastEthernet 6/0, Trap Source Address:192.168.120.78
Trap Proxy: enabled
Global Trap Severity Level: 6 - informational

Address          Security String                   Ver  Port   Trap Categories
---------------  --------------------------------  ---  -----  ----------------
192.168.1.1      host1                             v1   162    Cli
192.168.57.103   fredMirrorUser                    v3   162    CliPacketMirror
192.168.57.162   host2                             v3   162    Sonet


Address         TrapSeverityFilter  Ping    Maximum    Queue    Queue Full
                                    TimeOut QueueSize DrainRate discrd methd
--------------- ------------------- ------- --------- --------- -------------
192.168.1.1     5 - notice          1       32        0         dropLastIn
192.168.57.103  5 - notice          1       32        0         dropLastIn
192.168.57.162  2 - critical        1       32        0         dropLastIn
```

Capturing SNMP Secure Audit Logs

SNMP secure audit logging enables administrators to collect the SNMP audit logs for mirror traps and Mirror-MIB get/set operations with the protection of the mirror enabling feature. Secure audit logging facilitates the debugging of issues related to SNMP packet mirror traps.

All normal SNMP console and syslog audit logs (including snmpTrap, snmpPduAudit, and snmpSetPduAudit) for secure traps and Mirror-MIB are suppressed due to security concerns. When you have issued the **mirror enable** command, you can issue the **snmp secure-log** command to capture secure audit logs. Configuration, storage, and display of the SNMP secure logging is on global basis rather than a per-VR basis.

The SNMP agent captures and stores the audit logs for secure traps. The SNMP agent also captures PDU audit logs for Mirror-MIB operations. Configure the snmpTrap, snmpPduAudit, and snmpSetPduAudit logs at the proper severity level to capture the secure audit logs.

You can use the **show snmp secure-log** command to display the captured secure logs. Secure logs are stored in a string format similar to SNMP trap audit logs. You can use the **snmp-server clear secure-log** command to reset the secure logs.

The secure log configuration and data are not persistent. Secure audit logs are not available after a warm or cold restart of the SNMP agent, because the SNMP agent does not store the secure logs in NVS. The SNMP agent can store a maximum of 100 secure logs before overwriting the logs.

To enhance security, you can configure and display the secure audit logs only through the CLI. You cannot use SNMP to configure and display the logs. Secure trap logs are not populated in the notification logs MIB. From the perspective of the notification log MIB, secure traps do not exist.

Related Topics

- **snmp-server clear secure-log** command
- **snmp-server secure-log** command
- **show snmp secure-log** command
- **show snmp trap** command

Chapter 14

Monitoring Packet Mirroring

This chapter contains the following topics:

Monitoring Packet Mirroring Overview

Packet mirroring enables you to send a copy of a packet to an external host for analysis. Packet mirroring has many uses, including traffic debugging and troubleshooting user networking problems.

This topic describes the commands you can use to view your CLI-based and RADIUS-based packet mirroring environments.

Use the **baseline radius dynamic-request** command in RADIUS-based packet mirroring to set a statistics baseline for packet mirroring–related RADIUS statistics. The E-series router implements the baseline by reading and storing the statistics at the time the baseline is set and then subtracting this baseline when you retrieve baseline-relative statistics. Use the **delta** keyword with the **show radius statistics** command to show baselined statistics.

Related Topics

- **baseline radius dynamic-request** command
- **clear mirror log** command

Monitoring CLI-Based Packet Mirroring

Purpose Display brief or default (normal) information about your CLI-based packet mirroring environment, including interface analyzer information. To display secure packet mirroring information you must enable the **mirror-enable** command prior to using this command. This command displays a maximum of two secure policy attachments and statistics, if configured.

Action To display the default (normal) format for a specific interface, which is used as the default analyzer interface:

```
host1#show ip interface atm 5/0.1
ATM5/0.1 line protocol Atm1483 is up, ip is analyzer (default)
  Network Protocols: IP
  Internet address is 10.10.3.4/255.255.255.0
  Broadcast address is 255.255.255.255
  Operational MTU = 0  Administrative MTU = 0
  Operational speed = 100000000  Administrative speed = 0
  Discontinuity Time = 0
  Router advertisement = disabled
  Proxy Arp = disabled
  Administrative debounce-time = disabled
  Operational debounce-time    = disabled
  Access routing = disabled
  Multipath mode = hashed

  In Received Packets 0, Bytes 0
    Unicast Packets 0, Bytes 0
    Multicast Packets 0, Bytes 0
  In Policed Packets 0, Bytes 0
  In Error Packets 0
  In Invalid Source Address Packets 0
  In Discarded Packets 0
  Out Forwarded Packets 0, Bytes 0
    Unicast Packets 0, Bytes 0
    Multicast Routed Packets 0, Bytes 0
  Out Scheduler Dropped Packets 0, Bytes 0
  Out Policed Packets 0, Bytes 0
  Out Discarded Packets 0
```

To display the format for a specific interface, showing secure policy attachments:

```
host1#show ip interface atm 4/1.1
ATM5/0.1 line protocol Atm1483 is up
  Network Protocols: IP
  Internet address is 10.10.7.14/255.255.255.0
  Broadcast address is 255.255.255.255
  Operational MTU = 0  Administrative MTU = 0
  Operational speed = 100000000  Administrative speed = 0
  Discontinuity Time = 0
  Router advertisement = disabled
  Proxy Arp = disabled
  Administrative debounce-time = disabled
```

```
Operational debounce-time    = disabled
Access routing = disabled
Multipath mode = hashed

In Received Packets 0, Bytes 0
  Unicast Packets 0, Bytes 0
  Multicast Packets 0, Bytes 0
In Policed Packets 0, Bytes 0
In Error Packets 0
In Invalid Source Address Packets 0
In Discarded Packets 0
Out Forwarded Packets 0, Bytes 0
  Unicast Packets 0, Bytes 0
  Multicast Routed Packets 0, Bytes 0
Out Scheduler Dropped Packets 0, Bytes 0
Out Policed Packets 0, Bytes 0
Out Discarded Packets 0

IP policy secure-input ipSecureIn
  classifier-group secClassA entry 1
    0 packets, 0 bytes
    mirror analyzer-ip-address 10.10.3.14, analyzer-virtual-router default
  classifier-group secClassB entry 2
    0 packets, 0 bytes
    mirror analyzer-ip-address 10.10.3.14, analyzer-virtual-router vr200
IP policy secure-output ipSecureOut
  classifier-group secClassC entry 1
    0 packets, 0 bytes
    mirror analyzer-ip-address 10.10.7.104, analyzer-virtual-router vr300
```

Meaning Table 51 lists the secure packet mirroring-related fields.

Table 51: show ip interface Output Fields

Field Name	Field Description
IP Policy	Type (secure-input, secure-output) and name of the secure policy
classifier-group	Name of a CLACL attached to the interface and number of entry
packets	Number of packets classified by the CLACL
bytes	Number of bytes classified by the CLACL
mirror analyzer-ip-address	IP address of analyzer device
analyzer-virtual-router	Name of analyzer interface virtual router

Related Topics

- **show ip interface** command

Monitoring the Packet Mirroring Configuration of IP Interfaces

Purpose Display CLI-based packet mirroring configuration information for a specific interface or for all interfaces on which mirroring is enabled.

NOTE: This command is deprecated and might be removed completely in a future release. The function provided by this command has been replaced by the **show secure policy-list** command.

Action To display information about a specific interface or for all interfaces:

```
host1#show ip mirror interface atm 5/0.1

    Interface          Analyzer Port      Analyzer next-hop
------------------- ------------------- ---------------------
ATM5/0.1            FastEthernet3/0       192.168.1.1
```

Meaning Table 52 lists the **show ip mirror interface** command output fields.

Table 52: show ip mirror interface Output Fields

Field Name	Field Description
Interface	Interface being mirrored
Analyzer Port	Interface to which the mirrored traffic is sent, and that then sends the traffic to the analyzer device
Analyzer next-hop	IP address of the next hop to the analyzer device; displayed when the analyzer interface is a shared medium

Related Topics

- **show ip mirror interface** command

Monitoring Failure Messages for Secure Policies

Purpose Display failure messages and information for secure policies. This command and the output are visible only to authorized users—the **mirror-enable** command must be enabled prior to using this command. All normal E-series system log messages are suppressed for packet mirroring-related policy operations.

Action To display information for secure policies:

```
host1#show mirror log

   Time       Mirror-ID      Session-ID   User          Error Status
----------- ---------------- ---------- ---------- ----------------------
TUE FEB 03  8976             1923       suresh@aol no secure polic
2004 18:35                              .com       ies available
:43 UTC

TUE FEB 03  8976             1924       219040@aol out of memory
2004 18:35                              .com
:39 UTC
```

```
TUE FEB 03  8976            1924       not applic analyzer 1.1.1.1 is unr
:30 UTC                                able       eachble in virtual rou
                                                  ter default
```

Meaning Table 53 lists the **show mirror log** command output fields.

Table 53: show mirror log Output Fields

Field Name	Field Description
Time	Day, date, and time of failure
Mirror-ID	Unique identifier of the mirrored session
Session-ID	Unique identifier of the user session
User	User login name
Error Status	Description of error condition

Related Topics

- **show mirror log** command

Monitoring Packet Mirroring Triggers

Purpose Display CLI-based packet mirroring information about all packet mirroring triggers (active and inactive) that are configured on the router. This command and the output are visible only to authorized users—the **mirror-enable** command must be enabled prior to using this command.

Action To display information about all packet mirroring triggers:

```
host1#show mirror rules

Total Mirror Rules Configured: 6

Subscriber ID                 Subscriber ID       Secure Policy  Secure Policy List  Sessions
                              Method              Type                               Mirrored
-------------------           ------------------  -------------  ------------------  --------
default: user@isp250.com      username            ip             securePolicyIp      4
vpn: fred@isp100.com          username            ip             securePolicyVpn     0
default: 192.168.10.1         ip address          ip             securePolicyIp      1
vpn: 10.10.2.2                ip address          l2tp           securePolicyVpn     0
5551212                       calling station id  l2tp           securePolicyL2tp    1
erx atm 2/1.2:0.42:0001048579 acct-session-id     ip             securePolicyIp      1
```

Meaning Table 54 lists **show mirror rules** command output fields.

Table 54: show mirror rules Output Fields

Field Name	Field Description
Subscriber ID	Identification of the subscriber
Subscriber ID Method	Method used to identify the subscriber
Secure Policy Type	Type of secure policy; IP or L2TP
Secure Policy List	Name of secure policy list used for packet mirroring
Sessions Mirrored	Number of sessions currently being mirrored

Related Topics

- **show mirror rules** command

Monitoring Packet Mirroring Subscriber Information

Purpose Display CLI-based packet mirroring information about the subscribers for whom packet mirroring is currently active. This command and the output are visible only to authorized users—the **mirror-enable** command must be enabled prior to using this command.

Action To display information about subscribers for whom packet mirroring is active:

```
host1#show mirror subscribers

Subscriber ID                Subscriber ID       Secure Policy  Secure Policy List  Sessions
                             Method              Type                               Mirrored
-----------------            ------------------  -------------  ------------------  --------
vpn: fred@isp100.com         username            l2tp           securePolicyL2tp    1
5551212                      calling station id  ip             securePolicyVpn     1
```

Meaning Table 55 lists **show mirror subscribers** command output fields.

Table 55: show mirror subscribers Output Fields

Field Name	Field Description
Subscriber ID	Subscriber being mirrored
Subscriber ID Method	Method used to identify the subscriber
Secure Policy Type	Type of secure policy; IP or L2TP
Secure Policy List	Name of secure policy list used for packet mirroring
Sessions Mirrored	Number of sessions being mirrored

Related Topics

- **show mirror subscribers** command

Monitoring RADIUS Dynamic-Request Server Information

Purpose Display RADIUS dynamic-request server configuration information and statistics.

Action To display RADIUS dynamic-request server configuration information:

```
host1#show radius dynamic-request servers

                RADIUS Request Configuration
                ----------------------------
                                          Change
                 Udp                        Of
 IP Address      Port   Disconnect   Authorization   Secret
-------------    ----   ----------   -------------   ------
192.168.2.3      1700   disabled     disabled        <NULL>
10.10.120.104    1700   disabled     disabled        mysecret

host1#show radius dynamic-request statistics
```

```
        RADIUS Request Statistics
        -------------------------
           Statistic              10.10.3.4
-----------------------------     -------
UDP Port                          1700
Disconnect Requests               0
Disconnect Accepts                0
Disconnect Rejects                0
Disconnect No Session ID          0
Disconnect Bad Authenticators     0
Disconnect Packets Dropped        0
CoA Requests                      0
CoA Accepts                       0
CoA Rejects                       0
CoA No Session ID                 0
CoA Bad Authenticators            0
CoA Packets Dropped               0
No Secret                         0
Unknown Request                   0

Invalid Addresses Received  :0
```

Meaning Table 56 lists **show rsdius dynamic-request statistics** command output fields.

Table 56: show radius dynamic-request statistics Output Fields

Field Name	Field Description
IP Address	IP address of the RADIUS server
Udp Port	Port on which the router listens for RADIUS server
Disconnect	Status of RADIUS-initiated disconnect feature, enabled or disabled
Change of Authorization	Status of change of authorization feature, enabled or disabled
Secret	Secret (key) used to connect to RADIUS server
Disconnect or CoA Requests	Number of RADIUS-initiated disconnect or CoA requests received
Disconnect or CoA Accepts	Number of RADIUS-initiated disconnect or CoA requests accepted
Disconnect or CoA Rejects	Number of RADIUS-initiated disconnect or CoA requests rejected
Disconnect or CoA No Session ID	Number of RADIUS-initiated disconnect or CoA messages rejected because the request did not include a session ID attribute
Disconnect or CoA Bad Authenticators	Number of RADIUS-initiated disconnect or CoA messages rejected because the calculated authenticator in the authenticator field of the request did not match
Disconnect or CoA Packets Dropped	Number of RADIUS-initiated disconnect or CoA packets dropped because of queue overflow
No Secret	Number of messages rejected because a secret was not present in the authenticator field
Unknown Request	Number of packets received with an invalid RADIUS code for RADIUS disconnect or change of authorization
Invalid Addresses Received	Number of invalid addresses received

Related Topics

- **show radius servers** command
- **show radius statistics** command

Monitoring Secure CLACL Configurations

Purpose Display information about only secure CLACL configurations. This command and the output are visible only to authorized users—the **mirror-enable** command must be enabled prior to using this command. Use the **brief** or **detail** keywords with the **show secure classifier-list** command to display different levels of information.

Action To display a list of secure CLACLs

```
host1#show secure classifier-list

                        Classifier Control List Table
                        ---------- ------- ---- -----
Secure IP secClassA.1 ip any any
Secure IP secClassB.1 ip any not 10.10.10.1 255.255.255.255
Secure IP secClass25.1 user-packet-class 8 source-route-class 100 ip
192.168.44.103 255.255.255.255 any
```

Displays details of each secure CLACL

```
host1#show secure classifier-list secClass25 detailed

                        Classifier Control List Table
                        ---------- ------- ---- -----
Secure IP Classifier Control List secClass25
   Reference count:      0
   Entry count:          1

   Classifier-List secClass25 Entry 1
      User Packet Class:          8
      Source Route Class:         100
      Protocol:                   ip
      Not Protocol:               false
      Source IP Address:          192.168.44.103
      Source IP WildcardMask:     255.255.255.255
      Not Source Ip Address:      false
      Destination IP Address:     0.0.0.0
      Destination IP WildcardMask:255.255.255.255
      Not Destination Ip Address: false
```

Meaning Table 57 lists **show secure classifier-list** command output fields.

Table 57: show secure classifier-list Output Fields

Field Name	Field Description
Reference count	Number of times the CLACL is referenced by policies
Entry count	Number of entries in the classifier list
Classifier-List	Name of the classifier list
Entry	Entry number of the classifier list rule
Color	Packet color to match: green, yellow, or red

Table 57: show secure classifier-list Output Fields (continued)

Field Name	Field Description
Protocol	Protocol type
Not Protocol	If true, matches any protocol except the preceding protocol; if false, matches the preceding protocol
Source IP Address	Address of the network or host from which the packet is sent
Source IP WildcardMask	Mask that indicates addresses to be matched when specific bits are set
Not Source Ip Address	If true, matches any source IP address and mask except the preceding source IP address and mask; if false, matches the preceding source IP address and mask
Destination IP Address	Number of the network or host from which the packet is sent
Destination IP WildcardMask	Mask that indicates addresses to be matched when specific bits are set
Not Destination Ip Address	If true, matches any destination IP address and mask except the preceding destination IP address and mask; if false, matches the preceding destination IP address and mask
Traffic Class	Name of the traffic class to match
User Packet Class	User packet value to match
DS Field	DS field value to match
TOS Byte	ToS value to match
Precedence	Precedence value to match
User Priority bits	User priority bits value to match
Traffic Class Field	Traffic class field value to match
EXP Bits	MPLS EXP bit value to match
EXP Mask	Mask applied to EXP bits before matching
DE Bit	Frame Relay DE bit value to match
Destination Route Class	Route class used to classify packets based on the packet's destination address
Source Route Class	Route class used to classify packets based on the packet's source address
Local	If true, matches packets destined to a local interface; if false, matches packets that are traversing the router

Related Topics

- **show secure classifier-list** command

Monitoring Secure Policy Lists

Purpose Display information about only secure policy lists. This command and the output are visible only to authorized users—the **mirror-enable** command must be enabled prior to using this command. Use the **name** keyword to display information for a specific secure policy list.

Action To display information about secure policy lists:

```
host1#show secure policy-list

                                  Policy Table
                                  ------ -----
Secure IP Policy secureIpPolicy
   Administrative state: enable
   Reference count:      2
   Classifier control list: secClassA
      mirror analyzer-ip-address 192.168.1.1 analyzer-virtual-router default
analyzer-udp-port 3000 mirror-id 6789 session-id 6543

   Referenced by interface(s):
      ATM5/0.1  secure-input policy, statistics disabled, virtual-router
default
      ATM5/0.1  secure-output policy, statistics disabled, virtual-router
default

L2TP Secure Policy secureL2tpPolicy
   Administrative state: enable
   Reference count:      2
   Classifier control list: *
      mirror analyzer-ip-address 192.168.2.1 analyzer-virtual-router default
analyzer-udp-port 3000 mirror-id 6789 session-id 6543 (unreachable)

   Referenced by interface(s):
      TUNNEL l2tp:1/msn.pwh.com/1  secure-input policy, statistics disabled
      TUNNEL l2tp:1/msn.pwh.com/1  secure-output policy, statistics disabled
```

Meaning Table 58 lists **show secure policy-list** command output fields.

Table 58: show secure policy-list Output Fields

Field Name	Field Description
Policy	Type (IP or L2TP) and name of the policy list
Administrative state	Status of administrative state, enable or disable; set to enable when the policy list is created
Reference count	Number of attachments to interfaces or profiles
Classifier control list	Name of the classifier control list
Mirror analyzer-ip-address	IP address of analyzer device
Analyzer-virtual-router	Analyzer interface virtual router
Analyzer-udp-port	UDP port used to communicate with analyzer device
Mirror-id	Unique identifier of the mirrored session
Session-id	Unique identifier of the user session

Table 58: show secure policy-list Output Fields (continued)

Field Name	Field Description
Referenced by interface(s)	List of interfaces to which the policy is attached; indicates whether the attachment is at secure input or secure output of interface
Referenced by profile(s)	Not currently supported: always null
Statistics	Not currently supported: always disabled

Related Topics

- **show secure policy-list** command

Monitoring Information for Secure Policies

Purpose Display failure messages and information for secure policies. This command and the output are visible only to authorized users—the **mirror-enable** command must be enabled prior to using this command. All normal E-series system log messages are suppressed for packet mirroring-related policy operations.

Action To display information for secure policies:

```
host1#show mirror log

  Time              Mirror-ID      Session-ID   User           Error Status
-----------        ---------------- ---------- --------------  --------------
TUE FEB 03         8976             1923       suresh@aol.com  no secure policies available
2005 18:35:43 UTC

TUE FEB 03         8976             1924       219040@aol.com  out of memory
2005 18:35:39 UTC

TUE FEB 03         8976             1924       not applicable  analyzer unreachable
2005 18:35:30 UTC
```

Meaning

- Table 59 lists the **show mirror log** command output fields.

Table 59: show mirror log Output Fields

Field Name	Field Description
Time	Day, date, and time of failure
Mirror-ID	Unique identifier of the mirrored session
Session-ID	Unique identifier of the user session
User	User login name
Error Status	Description of the error condition

Related Topics

- **clear mirror log** command
- **show mirror log** command

Monitoring SNMP Secure Packet Mirroring Traps

Purpose Display configuration information about SNMP traps and trap destinations. The PacketMirror trap category is displayed only when the **mirror enable** command has been configured. The Secure Trap Logging status is displayed only when the **mirror enable** command has been issued and secure audit logs have been configured.Text in bold indicates secure packet mirroring trap configuration information.

Action To display secure packet mirroring traps:

```
host1#show snmp trap

Enabled Categories: CliSecurity, PacketMirror, Sonet
SNMP authentication failure trap is disabled
Trap Source: FastEthernet 6/0, Trap Source Address:192.168.120.78
Trap Proxy: enabled
Secure Trap Logging is enabled

Global Trap Severity Level: 6 - informational

Address          Security String                  Ver  Port   Trap Categories
---------------  -------------------------------  ---  -----  ----------------
10.1.1.1         host1                            v1     162  Cli
10.12.12.12      secureHost                       v3     162  CliOspfPacketMirrorSonet
192.168.57.162   host2                            v3     162  Sonet


Address         TrapSeverityFilter  Ping    Maximum    Queue    Queue Full
                                    TimeOut QueueSize DrainRate discrd methd
--------------- ------------------- ------- --------- --------- -------------
10.1.1.1        5 - notice          1       32        0         dropLastIn
10.12.12.12     2 - critical        1       32        0         dropLastIn
192.168.57.162  2 - critical        1       32        0         dropLastIn
```

Meaning Table 60 lists the **show snmp trap** command output fields.

Table 60: show snmp trap Output Fields

Field Name	Field Description
Enabled Categories	Trap categories that are enabled on the router
SNMP authentication failure trap	Enabled or disabled
Trap Source	Interface whose IP address is used as the source address for all SNMP traps
Trap Source Address	IP address used as the source address for all SNMP traps
Trap Proxy	Enabled or disabled
Secure Trap Logging	Enabled or disabled
Global Trap Severity Level	Global severity level filter; if a trap does not meet this severity level, it is discarded
Address	IP address of the trap recipient
Security String	Name of the SNMP community
Ver	SNMP version (v1 or v2) of the SNMP trap packet
Port	UDP port on which the trap recipient accepts traps

Table 60: show snmp trap Output Fields (continued)

Field Name	Field Description
Trap Categories	Types of traps that the trap recipient can receive
TrapSeverityFilter	Severity level filter for this SNMP host
Ping TimeOut	Configured ping timeout in minutes
Maximum QueueSize	Maximum number of traps to be kept in the trap queue
Queue DrainRate	Maximum number of traps per second to be sent to the host
Queue Full discrd methd	Method used to discard traps when the queue is full:
dropFirstIn	Oldest trap in the queue is dropped
dropLastIn	Most recent trap is dropped

Related Topics

- **mirror trap-enable** command
- **snmp-server enable traps** command
- **snmp-server host** command
- **snmp-server secure-log** command
- **show mirror trap** command
- **show snmp trap** command

NOTE: Secure packet mirroring trap configuration information appears in the Enabled Categories and Trap Categories fields only if the **mirror-enable** command is enabled.

Monitoring SNMP Secure Audit Logs

Purpose Display output when the secure audit log data is available.

Action To display the contents of the SNMP secure audit log:

```
host1#show snmp secure-log

Agent's Context    LogData
---------------    ------------------------------------------------------------
SnmpRouterAgent1   SNMP Trap, SNMPVer= 3, src=10.27.120.117, dest=10.1.1.1,
reqId=3, errSts=0, errIndx=0, msgID=2, msgMaxSize=1500, msgFlags=0,
msgSecurityModel=3,
contextEngineID=80:00:13:0a:05:00:90:1a:41:45:51:80:00:00:01 ,
securityName=jbond, engineBoots=0, engineTime=0, varCnt=13, Vars:
1.3.6.1.2.1.1.3.0 [1259], 1.3.6.1.6.3.1.1.4.1.0
1],3.6.1.4.1.4874.2.2.77.3.0.3], 1.3.6.1.4.1.4874.2.2.77.3.1.13 [?^K^B
1.3.6.1.4.1.4874.2.2.77.3.1.5 [0], 1.3.6.1.4.1.4874.2.2.77.3.1.4 [0],
1.3.6.1.4.1.4874.2.2.77.3.1.3 [f], 1.3.6.1.4.1.4874.2.2.77.3.1.14 [1],
1.3.6.1.4.1.4874.2.2.77.3.1.1 [1], 1.3.6.1.4.1.4874.2.2.77.3.1.2 [1],
```

```
1.3.6.1.4.1.4874.2.2.77.3.1.11 [f], 1.3.6.1.4.1.4874.2.2.77.3.1.12 [1],
1.3.6.1.4.1.4874.2.2.77.3.1.15 [0], 1.3.6.1.4.1.4874.2.2.16.1.3.5.0 [5],

SnmpRouterAgent44   SNMP Trap, SNMPVer= 3, src=10.27.120.117, dest=10.1.1.1,
reqId=5, errSts=0, errIndx=0, msgID=4, msgMaxSize=1500, msgFlags=0,
msgSecurityModel=3,
contextEngineID=80:00:13:0a:05:00:90:1a:41:45:51:80:00:00:01 ,
securityName=jbond, engineBoots=0, engineTime=0, varCnt=14, Vars:
1.3.6.1.2.1.1.3.0 [1259], 1.3.6.1.6.3.1.1.4.1.0
1],3.6.1.4.1.4874.2.2.77.3.0.1], 1.3.6.1.4.1.4874.2.2.77.3.1.13 [?^K^B
1.3.6.1.4.1.4874.2.2.77.3.1.5 [0], 1.3.6.1.4.1.4874.2.2.77.3.1.4 [0],
1.3.6.1.4.1.4874.2.2.77.3.1.3 [f], 1.3.6.1.4.1.4874.2.2.77.3.1.14 [1],
1.3.6.1.4.1.4874.2.2.77.3.1.10 [f], 1.3.6.1.4.1.4874.2.2.77.3.1.1 [1],
1.3.6.1.4.1.4874.2.2.77.3.1.2 [1], 1.3.6.1.4.1.4874.2.2.77.3.1.6 [0],
1.3.6.1.4.1.4874.2.2.77.3.1.8 [0], 1.3.6.1.4.1.4874.2.2.77.3.1.7 [f],
1.3.6.1.4.1.4874.2.2.16.1.3.5.0 [3],

SnmpRouterAgent22   SNMP Trap, SNMPVer= 3, src=10.27.120.117, dest=10.1.1.1,
reqId=8, errSts=0, errIndx=0, msgID=7, msgMaxSize=1500, msgFlags=3,
msgSecurityModel=3,
contextEngineID=80:00:13:0a:05:00:90:1a:41:45:51:80:00:00:01 ,
securityName=jbond, engineBoots=1, engineTime=8602, varCnt=6, Vars:
1.3.6.1.2.1.1.3.0 [1259], 1.3.6.1.6.3.1.1.4.1.0
1],3.6.1.4.1.4874.2.2.77.3.0.4], 1.3.6.1.4.1.4874.2.2.77.3.1.13 [?^K^B
1.3.6.1.4.1.4874.2.2.77.3.1.9 [192.168.7.120], 1.3.6.1.4.1.4874.2.2.77.3.1.14
[1], 1.3.6.1.4.1.4874.2.2.16.1.3.5.0 [4],
```

Meaning

- Table 61 lists the **show snmp secure-log** command output fields.

Table 61: show snmp secure-log Output Fields

Field Name	Field Description
Agent's Context	Owner of the secure log entry
LogData	Contents of the secure audit log

Related Topics

- **snmp-server clear secure-log** command
- **show snmp secure-log** command

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