



CHAPTER 36

Configuring Denial of Service Protection

This chapter contains information on how to protect your Cisco 7600 series router against Denial of Service (DoS) attacks. The information covered in this chapter is unique to the Cisco 7600 series routers, and it supplements the network security information and procedures in the “[Configuring Network Security](#)” chapter in this publication as well as the network security information and procedures in these publications:

- *Cisco IOS Security Configuration Guide*, Release 12.2, at this URL:
http://www.cisco.com/en/US/docs/ios/12_2/security/configuration/guide/fsecur_c.html
- The Cisco 7600 Series Routers Command References at this URL:
http://www.cisco.com/en/US/products/hw/routers/ps368/prod_command_reference_list.html

This chapter consists of these sections:

- [Understanding How DoS Protection Works](#), page 36-1
- [MLS Rate-limiter Default Configuration](#), page 36-13
- [DoS Protection Configuration Guidelines and Restrictions](#), page 36-14
- [Understanding How Control Plane Policing Works](#), page 36-19
- [CoPP Default Configuration](#), page 36-19
- [CoPP Configuration Guidelines and Restrictions](#), page 36-19
- [Configuring CoPP](#), page 36-21
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- [Personalizing CoPP](#), page 36-23
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- [Personalizing CoPP](#), page 36-23

Understanding How DoS Protection Works

The following sections contain an overview of the DoS protection on the Cisco 7600 series router and describe some types of DoS attack scenarios:

- [DoS Protection with a PFC3](#), page 36-2

DoS Protection with a PFC3

This section contains information about the available methods to counteract DoS attacks with a PFC3 and includes configuration examples. The PFC3 provides a layered defense against DoS attacks using the following methods:

- CPU rate limiters—Controls traffic types.
- Control plane policing (CoPP)—Filters and rate limits control plane traffic. For information about CoPP, see the [“Understanding How Control Plane Policing Works”](#) section on page 36-19.

These sections describe DoS protection with a PFC3:

- [Security ACLs and VACLs](#), page 36-2
- [QoS Rate Limiting](#), page 36-3
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Security ACLs and VACLs

If the network is under a DoS attack, ACLs can be an efficient method for dropping the DoS packets before they reach the intended target. Use security ACLs if an attack is detected from a particular host. In this example, the host 10.1.1.10 and all traffic from that host is denied:

```
Router(config)# access-list 101 deny ip host 10.1.1.10 any
Router(config)# access-list 101 permit ip any any
```

Security ACLs also protect against the spoofing of addresses. For example, assume that a source address A is on the inside of a network and a router interface that is pointing to the Internet. You can apply an inbound ACL on the router Internet interface that denies all addresses with a source of A (the inside address). This action stops attacks where the attackers spoof inside source addresses. When the packet arrives at the router interface, it matches on that ACL and drops the packet before it causes damage.

When the Cisco 7600 series router is used with a Cisco Intrusion Detection Module (CIDM), you can dynamically install the security ACL as a response to the detection of the attack by the sensing engine.

VACLs are a security enforcement tool based on Layer 2, Layer 3, and Layer 4 information. The result of a VACL lookup against a packet can be a permit, a deny, a permit and capture, or a redirect. When you associate a VACL with a particular VLAN, all traffic must be permitted by the VACL before the traffic is allowed into the VLAN. VACLs are enforced in hardware, so there is no performance penalty for applying VACLs to a VLAN on the Cisco 7600 series routers.

QoS Rate Limiting

QoS ACLs limit the amount of a particular type of traffic that is processed by the MSFC3. If a DoS attack is initiated against the MSFC, QoS ACLs can prevent the DoS traffic from reaching the MSFC data path and congesting it. The PFC3 performs QoS in hardware, which offers an efficient means of limiting DoS traffic (once that traffic has been identified) to protect the router from impacting the MSFC.

For example, if the network is experiencing ping-of-death or smurf attacks, the administrator should rate limit the ICMP traffic to counteract the DoS attack and still allow legitimate traffic through the processor, or allow it to be forwarded to the MSFC or host. This rate limiting configuration must be done for each flow that should be rate limited and the rate-limiting policy action should be applied to the interface.

In the following example, the access-list 101 permits and identifies ping (echo) ICMP messages from any source to any destination as traffic. Within the policy map, a policing rule defines a specified committed information rate (CIR) and burst value (96000 bps and 16000 bps) to rate limit the ping (ICMP) traffic through the chassis. The policy map then is applied to an interface or VLAN. If the ping traffic exceeds the specified rate on the VLAN or interface where the policy map is applied, it is dropped as specified in the markdown map (the markdown map for the normal burst configurations is not shown in the example).

```
Router(config)# access-list 101 permit icmp any any echo
Router(config)# class-map match-any icmp_class
Router(config-cmap)# match access-group 101
Router(config-cmap)# exit
Router(config)# policy-map icmp_policer
Router(config-pmap)# class icmp_class
Router(config-pmap-c)# police 96000 16000 conform-action transmit exceed-action
policed-dscp-transmit drop
Router(config-pmap-c)# exit
Router(config-pmap)# exit
```

uRPF Check

When you enable the unicast reverse path forwarding (uRPF) check, packets that lack a verifiable source IP address, such as spoofed IP source addresses, are discarded. Cisco Express Forwarding (CEF) tables are used to verify that the source addresses and the interfaces on which they were received are consistent with the FIB tables on the supervisor engine.

After you enable uRPF check on an interface (per-VLAN basis), the incoming packet is compared to the CEF tables through a reverse lookup. If the packet is received from one of the reverse path routes, the packet is forwarded. If there is no reverse path route on the interface on which the packet was received, the packet fails the uRPF check and is either dropped or forwarded, depending on whether an ACL is applied to the uRPF check fail traffic. If no ACL is specified in the CEF tables, then the forged packets are immediately dropped.

You can only specify an ACL for the uRPF check for packets that fail the uRPF check. The ACL checks whether the packet should immediately be dropped or forwarded. The uRPF check with ACL is not supported in any PFC3 in hardware. Packets that are denied in the uRPF ACL are forwarded in hardware. Packets that are permitted are sent to the CPU.

The uRPF check with a PFC3 is supported in hardware. However, all packets that fail the uRPF check, and are forwarded because of an applied ACL, can be sent and rate limited to the MSFC to generate ICMP unreachable messages; these actions are all software driven. The uRPF check in hardware is supported for routes with up to two return paths (interfaces) and up to six return paths with interface groups configured (two from the FIB table and four from the interface groups).

Traffic Storm Control

A traffic storm occurs when packets flood the LAN, which creates excessive traffic and degrades network performance. The traffic storm control feature prevents LAN ports from being disrupted by a broadcast, multicast, or unicast traffic storm on physical interfaces from either mistakes in network configurations or from users issuing a DoS attack. Traffic storm control (also called traffic suppression) monitors incoming traffic levels over a 1-second traffic storm control interval. During the interval, traffic storm control compares the traffic level with the configured traffic storm control level. The traffic storm control level is a percentage of the total available bandwidth of the port. Each port has a single traffic storm control level that is used for all types of traffic (broadcast, multicast, and unicast).

Traffic storm control is configured on an interface and is disabled by default. The configuration example here enables broadcast address storm control on interface FastEthernet 2/3 to a level of 20 percent. When the broadcast traffic exceeds the configured level of 20 percent of the total available bandwidth of the port within a 1-second traffic-storm-control interval, traffic storm control will drop all broadcast traffic until the end of the traffic-storm-control interval.

```
Router(config-if)# storm-control broadcast level 20
```

The Cisco 7600 series router supports broadcast storm control on all LAN ports and multicast and unicast storm control on Gigabit Ethernet ports.

When two or three suppression modes are configured simultaneously, they share the same level settings. If broadcast suppression is enabled, and if multicast suppression is also enabled and configured at a 70-percent threshold, the broadcast suppression will also have a setting for 70 percent.

Network Under SYN Attack

A network under a SYN attack is easily recognized. The target host becomes unusually slow, crashes, or suspends operation. Traffic returned from the target host can also cause trouble on the MSFC because return traffic goes to randomized source addresses of the original packets, lacks the locality of “real” IP traffic, and may overflow route caches, or CEF tables.

When the network is under a SYN attack, the TCP intercept feature becomes aggressively defensive. Two factors determine when aggressive behavior on the router begins and ends:

- The total incomplete connections
- Connection requests during the last one-minute sample period

Both factors are configured with low and high values.

If the number of incomplete connections exceed 1,100, or the number of connections arriving in the last one-minute period exceed 1,100, each new arriving connection causes the oldest partial connection (or a random connection) to be deleted. These are the default values, which can be altered. When either of the thresholds is exceeded, the TCP intercept assumes the server is under attack and goes into aggressive mode with the following reactions:

- Each new arriving connection causes the oldest partial (or random partial) to be deleted.
- The initial retransmission timeout is reduced by half to 0.5 seconds, and so the total time trying to establish the connection is cut in half.
- In watch mode, the watch timeout is reduced by half.



Note When both thresholds fall below the configured low value, the aggressive behavior ceases (default value is 900 in both factors).

TCP flows are hardware assisted on all PFC3 types.

ARP Policing

During an attack, malicious users may try to overwhelm the MSFC CPU with control packets such as routing protocol or ARP packets. These special control packets can be hardware rate limited using a specific routing protocol and an ARP policing mechanism configured with the **mls qos protocol** command. The routing protocols supported include RIP, BGP, LDP, OSPF, IS-IS, IGRP, and EIGRP. For example, the command **mls qos protocol arp police 32000** rate limits ARP packets in hardware at 32,000 bps. Although this policing mechanism effectively protects the MSFC CPU against attacks such as line-rate ARP attacks, it does not only police routing protocols and ARP packets to the router but also polices traffic through the box with less granularity than CoPP.

The policing mechanism shares the root configuration with a policing-avoidance mechanism. The policing-avoidance mechanism lets the routing protocol and ARP packets flow through the network when they reach a QoS policer. This mechanism can be configured using the **mls qos protocol protocol pass-through** command.

This example shows how to display the available protocols to use with ARP policing.

```
Router(config)# mls qos protocol ?
  isis
  eigrp
  ldp
  ospf
  rip
  bgp
  ospfv3
  bgpv2
  ripng
  neigh-discover
  wlccp
  arp
```

This example shows how to display the available keywords to use with the **mls qos protocol arp** command:

```
Router(config)# mls qos protocol arp ?
  pass-through  pass-through keyword
  police        police keyword
  precedence    change ip-precedence(used to map the dscp to cos value)
```

Hardware-Based Rate Limiters on the PFC3

The PFC3 supports additional hardware-based rate limiters. The PFC3 provides eight rate-limiter registers for the new rate limiters, which are configured globally on the router. These rate-limiter registers are present in the Layer 3 forwarding engine (PFC) and are responsible for containing rate-limiting information for result packets that match the various available configured rate limiters.

Because eight rate-limiter registers are present on the PFC3, these registers can force different rate-limiting scenarios to share the same register. The registers are assigned on a first-come, first-serve basis. If all registers are being utilized, the only way to configure another rate limiter is to free one register.

The hardware-based rate limiters available on the PFC3 are as follows:

- Ingress and egress ACL bridged packets
- uRPF check failures
- FIB receive cases
- FIB glean cases
- Layer 3 security features
- ICMP redirects
- ICMP unreachable (ACL drop)
- No-route (FIB miss)
- VACL log
- TTL failure
- MTU failure
- Multicast IPv4
- Multicast IPv6

Shared Rate-Limiters

These shared rate-limiters can be configured on the router:

- IP RPF failure
- ICMP unreachable no-route
- ICMP unreachable acl-drop
- IP errors

If you enable/disable one of the share limiter, all the other shared limiters are enable/disabled.

Recommended Rate-Limiter Configuration

The recommended rate-limiter configuration is as follows:

- Enable the rate limiters for the traffic types most likely to be used in a DoS attack.
- Do not use a rate limiter on VACL logging unless you configure VACL logging.
- Disable redirects because a platform that supports hardware forwarding, such as the Cisco 7600 series router, reduces the need for redirects.

- TTL-Failure and CEF-Glean rate-limiters are not enabled by default. It is recommended to enable these rate-limiters.
- Do not enable the MTU rate limiter if all interfaces have the same MTU.
- When configuring the Layer 2 PDU rate limiter, note the following information:
 - Calculate the expected or possible number of valid PDUs and double or triple the number.
 - PDUs include BPDUs, DTP, VTP, PAgP, LACP, UDLD, etc.
 - Rate limiters do not discriminate between good frames or bad frames.
- The MTU and TTL rate limiters are enabled by default from the 12.2(33)SRE3 release onwards.
 - The default MTU and TTL values are 970 and 97 respectively. You can change the default values once the router is booted.
 - If non-default values on MTU and TTL have already been configured on the router, then the user defined configurations takes precedence.
 - The default values of MTU and TTL rate-limiters can be modified and saved in the configurations
 - If the maximum supported rate-limiters have already been configured, then the MTU and TTL rate-limiters are not enabled by default at the boot up. The user defined rate-limiters is given precedence.

Ingress-Egress ACL Bridged Packets (Unicast Only)

This rate limiter rate limits packets sent to the MSFC because of an ingress/egress ACL bridge result. The router accomplishes this by altering existing and new ACL TCAM entries with a TCAM bridge result to a Layer 3 redirect result pointing to the MSFC. Packets hitting the TCAM entries with the altered Layer 3 redirect rate limit result will be rate limited according to the instructions set in CLI by the network administrator. Both the ingress and egress values will be the same, as they both share the same rate-limiter register. If the ACL bridge ingress/egress rate limiting is disabled, the Layer 3 redirect rate limit results are converted to the bridge result.

Ingress or egress ACL-bridged packet cases share a single rate-limiter register. If the feature is turned on, ingress and egress ACLs use the same rate-limiter value.

Burst values regulate how many packets can be allowed in a burst. Each allowed packet consumes a token and a token must be available for a packet to be allowed. One token is generated per millisecond. When packets are not coming in, tokens can be accumulated up to the burst value. For example, if the burst value is set to 50, the router can accumulate up to 50 tokens and absorb a burst of 50 packets.

This example shows how to rate limit the unicast packets from an ingress ACL bridge result to 50000 packets per second, and 50 packets in burst:

```
Router(config)# mls rate-limit unicast acl input 50000 50
```

This example shows how to rate limit the unicast packets from an ingress ACL bridge result to the same rate (50000 pps and 50 packets in burst) for egress ACL bridge results:

```
Router(config)# mls rate-limit unicast acl output 50000 50
```

If the values of the rate limiter are altered on either the ingress or the egress when both are enabled, both values are changed to that new value. In the following example, the output rate is changed to 40000 pps:

```
Router(config)# mls rate-limit unicast acl output 40000 50
```

When you enter the **show mls rate-limit** command, both the ACL bridged in and the ACL bridged out display the new value of 40000 pps:

```
Router# show mls rate-limit
  Rate Limiter Type      Status      Packets/s      Burst
-----
MCAST NON RPF           Off         -              -
MCAST DFLT ADJ           On          100000         100
MCAST DIRECT CON         Off         -              -
ACL BRIDGED IN           On          40000          50
ACL BRIDGED OUT          On          40000          50
IP FEATURES              Off
...
```

uRPF Check Failure

The uRPF check failure rate limiter allows you to configure a rate for the packets that need to be sent to the MSFC because they failed the uRPF check. The uRPF checks validate that incoming packets on an interface are from a valid source, which minimizes the potential threat of DoS attacks from users using spoofed addresses. When spoofed packets fail the uRPF check, those failures can be sent to the MSFC. The uRPF check rate limiters allow you to rate limit the packets per second that are bridged to the MSFC CPU when a uRPF check failure occurs.

This example shows how to rate limit the uRPF check failure packets sent to the MSFC to 100000 pps with a burst of 100 packets:

```
Router(config)# mls rate-limit unicast ip rpf-failure 100000 100
```

TTL Failure

This rate limiter rate limits packets sent to the MSFC because of a time-to-live (TTL) check failure. As indicated by the **all** keyword in the following example, this rate limiter applies to both multicast and unicast traffic.



Note

The TTL failure rate limiter is not supported for IPv6 multicast.

This example shows how to rate limit the TTL failures to 70000 pps with a burst of 150:

```
Router(config)# mls rate-limit all ttl-failure 70000 150
```

ICMP Unreachable (Unicast Only)

In an ICMP unreachable attack, a device is flooded with a large number of packets that contain a destination address that is unreachable from the flooded device (in this case, the MSFC). The ICMP unreachable rate limiter allows you to rate limit the packets that are sent to the MSFC containing unreachable addresses.

This example shows how to rate limit the packets that are sent to the MSFC because of an ACL drop to 10000 pps and a burst of 100:

```
Router(config)# mls rate-limit unicast ip icmp unreachable acl-drop 10000 100
```

This example shows how to rate limit the packets that require generation of ICMP-unreachable messages because of a FIB miss to 80000 pps and burst to 70:

```
Router(config)# mls rate-limit unicast ip icmp unreachable no-route 80000 70
```

The four rate limiters, ICMP unreachable no route, ICMP unreachable ACL drop, IP errors, and IP RPF failure, share a single rate-limiter register. If any of these limiters are enabled, all of the limiters in this group will share the same value and sometimes the same state (for example, ON/ON/ON). When verifying the rate limiters, if the members of this register are enabled through another feature, an

ON-Sharing status (instead of an ON status) is displayed. The exception is the TTL failure rate limiter: its value shares the same value as the other members in the register if you have manually enabled the feature.

FIB (CEF) Receive Cases (Unicast Only)

The FIB receive rate limiter provides the capability to rate limit all packets that contain the MSFC IP address as the destination address. The rate limiters do not discriminate between good frames and bad frames.



Note

Do not enable the FIB receive rate limiter if you are using CoPP. The FIB receive rate limiter overrides the CoPP policies.

This example shows how to rate limit the traffic to 25000 pps with a burst of 60:

```
Router(config)# mls rate-limit unicast cef receive 25000 60
```

FIB Glean (Unicast Only)

The FIB glean rate limiter does not limit ARP traffic, but provides the capability to rate limit traffic that requires address resolution (ARP) and requires that it be sent to the MSFC. This situation occurs when traffic enters a port and contains the destination of a host on a subnet that is locally connected to the MSFC, but no ARP entry exists for that destination host. In this case, because the MAC address of the destination host will not be answered by any host on the directly connected subnet that is unknown, the “glean” adjacency is hit and the traffic is sent directly to the MSFC for ARP resolution. This rate limiter limits the possibility of an attacker overloading the CPU with such ARP requests.

This example shows how to rate limit the rate at which this traffic is sent to the MSFC to 20000 pps and a burst of 60:

```
Router(config)# mls rate-limit unicast cef glean 20000 60
```

Layer 3 Security Features (Unicast Only)

Some security features are processed by first being sent to the MSFC. For these security features, you need to rate limit the number of these packets being sent to the MSFC to reduce any potential overloading. The security features include authentication proxy (auth-proxy), IPSEC, and inspection.

Authentication proxy is used to authenticate inbound or outbound users or both. These users are normally blocked by an access list, but with auth-proxy, the users can bring up a browser to go through the firewall and authenticate on a terminal access controller access control system plus (TACACS+) or RADIUS server (based on the IP address). The server passes additional access list entries down to the router to allow the users through after authentication. These ACLs are stored and processed in software, and if there are many users utilizing auth-proxy, the MSFC may be overwhelmed. Rate limiting would be advantageous in this situation.

IPSec and inspection are also done by the MSFC and may require rate limiting. When the Layer 3 security feature rate limiter is enabled, all Layer 3 rate limiters for auth-proxy, IPSec and inspection are enabled at the same rate.

This example shows how to rate limit the security features to the MSFC to 100000 pps with a burst of 10 packets:

```
Router(config)# mls rate-limit unicast ip features 100000 10
```

ICMP Redirect (Unicast Only)

The ICMP-redirect rate limiter allows you to rate limit ICMP traffic. For example, when a host sends packets through a nonoptimal router, the MSFC sends ICMP-redirect messages to the host to correct its sending path. If this traffic occurs continuously, and is not rate limited, the MSFC will continuously generate ICMP-redirect messages.

This example shows how to rate limit the ICMP redirects to 20000 pps, with a burst of 20 packets:

```
Router(config)# mls rate-limit unicast ip icmp redirect 20000 20
```

VACL Log (Unicast Only)

Packets that are sent to the MSFC because of VLAN-ACL logging can be rate limited to ensure that the CPU is not overwhelmed with logging tasks. VACLs are processed in hardware, but the MSFC does the logging. When VACL logging is configured on the router, IP packets that are denied in the VACL generate log messages.

This example shows how to rate limit logging requests to 5000 pps (the range for this rate limiter is from 10 to 5000 pps):

```
Router(config)# mls rate-limit unicast acl vac1-log 5000
```

MTU Failure

Similar to the TTL failure rate limiter, the rate limiter for MTU failures is supported for both unicast and multicast traffic. Packets that fail an MTU check are sent to the MSFC CPU. This might cause the MSFC to be overwhelmed.

This example shows how to rate limit packets failing the MTU failures from being sent to the MSFC to 10000 pps with a burst of 10:

```
Router(config)# mls rate-limit all mtu 10000 10
```

Layer 2 Multicast IGMP Snooping

The IGMP snooping rate limiter limits the number of Layer 2 IGMP packets destined for the supervisor engine. IGMP snooping listens to IGMP messages between the hosts and the supervisor engine. You cannot enable the Layer 2 PDU rate limiter if the Cisco 7600 series router is operating in truncated mode. The router uses truncated mode for traffic between fabric-enabled modules when there are both fabric-enabled and non fabric-enabled modules installed. In this mode, the router sends a truncated version of the traffic (the first 64 bytes of the frame) over the switch fabric channel.

This example shows how to rate limit IGMP-snooping traffic:

```
Router(config)# mls rate-limit multicast ipv4 igmp 20000 40
```

Layer 2 PDU

The Layer 2 protocol data unit (PDU) rate limiter allows you to limit the number of Layer 2 PDU protocol packets (including BPDUs, DTP, PAgP, CDP, STP, and VTP packets) destined for the supervisor engine and not the MSFC CPU. You cannot enable the Layer 2 PDU rate limiter if the Cisco 7600 series router is operating in truncated mode. The router uses truncated mode for traffic between fabric-enabled modules when there are both fabric-enabled and non fabric-enabled modules installed. In this mode, the router sends a truncated version of the traffic (the first 64 bytes of the frame) over the switch fabric channel.

This example shows how to rate limit Layer 2 PDUs to 20000 pps with a burst of 20 packets.

```
Router(config)# mls rate-limit layer2 pdu 20000 20
```

Layer 2 Protocol Tunneling

This rate limiter limits the Layer 2 protocol tunneling packets, which include control PDUs, CDP, STP, and VTP packets destined for the supervisor engine. These packets are encapsulated in software (rewriting the destination MAC address in the PDU), and then forwarded to a proprietary multicast address (01-00-0c-cd-cd-d0). You cannot enable the Layer 2 PDU rate limiter if the Cisco 7600 series router is operating in truncated mode. The router uses truncated mode for traffic between fabric-enabled modules when there are both fabric-enabled and non fabric-enabled modules installed. In this mode, the router sends a truncated version of the traffic (the first 64 bytes of the frame) over the switch fabric channel.

This example shows how to rate limit Layer 2 protocol tunneling packets to 10000 pps with a burst of 10 packets:

```
Router(config)# mls rate-limit layer2 12pt 10000 10
```

IP Errors

This rate limiter limits the packets with IP checksum and length errors. When a packet reaches the PFC3 with an IP checksum error or a length inconsistency error, it must be sent to the MSFC for further processing. An attacker might use the malformed packets to carry out a DoS attack, but the network administrator can configure a rate for these types of packets to protect the control path.

This example shows how to rate limit IP errors sent to the MSFC to 1000 pps with a burst of 20 packets:

```
Router(config)# mls rate-limit unicast ip errors 1000 20
```

IPv4 Multicast

This rate limiter limits the IPv4 multicast packets. The rate limiters can rate limit the packets that are sent from the data path in the hardware up to the data path in the software. The rate limiters protect the control path in the software from congestion and drop the traffic that exceeds the configured rate. Within the IPv4 multicast rate limiter, there are three rate limiters that you can also configure: the FIB-miss rate limiter, the multicast partially switched flows rate limiter, and the multicast directly connected rate limiter.

The FIB-miss rate limiter allows you to rate limit the multicast traffic that does not match an entry in the mroute table.

The partially switched flow rate limiter allows you to rate limit the flows destined to the MSFC3 for forwarding and replication. For a given multicast traffic flow, if at least one outgoing Layer 3 interface is multilayer switched, and at least one outgoing interface is not multilayer switched (no H-bit set for hardware switching), the particular flow is considered partially switched, or partial-SC (partial shortcut). The outgoing interfaces that have the H-bit flag are switched in hardware and the remaining traffic is switched in software through the MSFC3. For this reason, it may be desirable to rate limit the flow destined to the MSFC3 for forwarding and replication, which might otherwise increase CPU utilization.

The multicast directly connected rate limiter limits the multicast packets from directly connected sources.

This example shows how to rate limit the multicast packets to 30000 pps with a burst of 30:

```
Router(config)# mls rate-limit multicast ipv4 connected 30000 30
```

The **ip-option** keyword and the ip-option rate limiter are supported with a PFC3B, PFC3BXL, PFC3C, or PFC3CXL only.

This example shows how to set the rate limiters for the IPv4 multicast packets failing the uRPF check:

```
Router(config)# mls rate-limit multicast ipv4 non-rpf 100
```

This example shows how to rate limit the multicast FIB miss packets to 10000 pps with a burst of 10:

```
Router(config)# mls rate-limit multicast ipv4 fib-miss 10000 10
```

This example shows how to rate limit the partial shortcut flows to 20000 pps with a burst of 20 packets:

```
Router(config)# mls rate-limit multicast ipv4 partial 20000 20
```

This example shows how to rate limit the multicast packets to 30000 pps with a burst of 20:

```
Router(config)# mls rate-limit multicast ipv4 connected 30000 20
```

This example shows how to rate limit IGMP-snooping traffic:

```
Router(config)# mls rate-limit multicast ipv4 igmp 20000 40
```

IPv6 Multicast

This rate limiter limits the IPv6 multicast packets. [Table 36-1](#) lists the IPv6 rate limiters and the class of traffic that each rate limiter serves.

Table 36-1 IPv6 Rate Limiters

Rate Limiter	Traffic Classes to be Rate Limited
Connected	Directly connected source traffic
Default-drop	* (*, G/m) SSM * (*, G/m) SSM non-rpf
Route-control	* (*, FF02::X/128)
Starg-bridge	* (*, G/128) SM * SM non-rpf traffic when (*, G) exists
Starg-M-bridge	* (*, G/m) SM * (*, FF/8) * SM non-rpf traffic when (*, G) doesn't exist

You can configure rate limiters for IPv6 multicast traffic using one of the following methods:

- Direct association of the rate limiters for a traffic class—Select a rate and associate the rate with a rate limiter. This example shows how to pick a rate of 1000 pps and 20 packets per burst and associate the rate with the **default-drop** rate limiter:

```
Router(config)# mls rate-limit multicast ipv6 default-drop 1000 20
```

- Static sharing of a rate limiter with another preconfigured rate limiter—When there are not enough adjacency-based rate limiters available, you can share a rate limiter with an already configured rate limiter (target rate limiter). This example shows how to share the **route-cntl** rate limiter with the **default-drop** target rate limiter:

```
Router(config)# mls rate-limit multicast ipv6 route-cntl share default-drop
```

If the target rate limiter is not configured, a message is displayed that indicates that the target rate limiter must be configured for it to be shared with other rate limiters.

- Dynamic sharing of rate limiters—If you are not sure about which rate limiter to share with, use the **share auto** keywords to enable dynamic sharing. When you enable dynamic sharing, the system selects a preconfigured rate limiter and shares the given rate limiter with the preconfigured rate limiter. This example shows how to choose dynamic sharing for the route-cntl rate limiter:

```
Router(config)# mls rate-limit multicast ipv6 route-cntl share auto
```

This example shows how to set the rate limiters for the IPv6 multicast packets from a directly connected source:

```
Router(config)# mls rate-limit multicast ipv6 connected 1500 20
```

This example shows how to configure a direct association of the rate limiters for a traffic class:

```
Router(config)# mls rate-limit multicast ipv6 default-drop 1000 20
```

This example shows how to configure the static sharing of a rate limiter with another preconfigured rate limiter:

```
Router(config)# mls rate-limit multicast ipv6 route-cntl share default-drop
```

This example shows how to enable dynamic sharing for the route control rate limiter:

```
Router(config)# mls rate-limit multicast ipv6 route-cntl share auto
```

MLS Rate-limiter Default Configuration

Table 36-2 shows the DoS protection default configuration for the PFC3 hardware-based rate limiters.

Table 36-2 PFC3 Hardware-based Rate Limiter Default Setting

Rate Limiter	Default Status (ON/OFF)	Default Value
Ingress/Egress ACL Bridged Packets	OFF	
RPF Failures	ON	100 pps, burst of 10 packets
FIB Receive cases	OFF	
FIB Glean Cases	OFF	
Layer 3 Security features	OFF	
ICMP Redirect	OFF	
ICMP Unreachable	ON	100 pps, burst of 10 packets
VACL Log	ON	2000 pps, burst of 10 packets
TTL Failure	OFF	
MTU Failure	OFF	
Layer 2 PDU	OFF	
Layer 2 Protocol Tunneling	OFF	
IP Errors	ON	100 pps, burst of 10 packets
Multicast IGMP	OFF	
Multicast FIB-Miss	ON	100000 pps, burst of 100 packets
Multicast Partial-SC	ON	100000 pps, burst of 100 packets
Multicast Directly Connected	OFF	

Table 36-2 PFC3 Hardware-based Rate Limiter Default Setting (continued)

Rate Limiter	Default Status (ON/OFF)	Default Value
Multicast Non-RPF	OFF	
Multicast IPv6	ON	If the <i>packets-in-burst</i> is not set, a default of 100 is programmed for multicast cases.

DoS Protection Configuration Guidelines and Restrictions

The section contains these configuration guidelines and restrictions:

- [PFC3, page 36-14](#)

PFC3

When configuring DoS protection on systems configured with a PFC3, follow these CPU rate limiter guidelines and restrictions:



Note

For the CoPP guidelines and restrictions, see the [“CoPP Configuration Guidelines and Restrictions” section on page 36-19](#).

- Do not use these rate limiters if multicast is enabled in systems configured with a PFC3A:
 - TTL failure
 - MTU failure
- These rate limiters are supported only on a PFC3B, PFC3BXL, PFC3C, or PFC3CXL:
 - Unicast IP options
 - Multicast IP options
- These are Layer 2 rate limiters:
 - Layer 2 PDUs
 - Layer 2 protocol tunneling
 - Layer 2 Multicast IGMP
- There are eight Layer 3 registers and two Layer 2 registers that can be used as CPU rate limiters.
- Do not use the CEF receive limiter if CoPP is being used. The CEF receive limiter will override the CoPP traffic.
- Rate limiters override the CoPP traffic.
- Configured rate limits is applied to each forwarding engine (except for the Layer 2 hardware rate limiter which is applied globally).
- Layer 2 rate limiters are not supported in truncated mode.
- The following restrictions apply when using the ingress and egress ACL-bridged packet rate limiters:
 - The ingress and egress ACL-bridged packet rate limiter is available for unicast traffic only.

- The ingress and egress ACL-bridged packet rate limiters share a single rate-limiter register. If you enable the ACL-bridge ingress and egress rate limiters, both the ingress and the egress ACLs must share the same rate-limiter value.
- Use the **mls rate-limit unicast** command to rate limit unicast traffic.
- Use the **mls rate-limit multicast** command to rate limit multicast traffic.
- Use the **mls rate-limit multicast layer 2** command to rate limit Layer 2 multicast traffic.

Monitoring Packet Drop Statistics

You can capture the incoming or outgoing traffic on an interface and send a copy of this traffic to an external interface for monitoring by a traffic analyzer. To capture traffic and forward it to an external interface, use the **monitor session** command.

When capturing traffic, these restrictions apply:

- The incoming captured traffic is not filtered.
- The incoming captured traffic is not rate limited to the capture destination.
- In mls qos policer, if confirm action and exceed action are the same (transmit), packets are not dropped. Hence, when you execute the **show policy-map interface** command, you cannot view the packet count in the dropped counters. If exceed action is modified to police, DSCP etc (other than transmit), then the exceed action occurs on the packets.
- Mls rate-limiter statistics are not available as no hardware resource is present in PFC/DFC.

Monitoring Dropped Packets Using Monitor Session Commands

This example shows how to use the **monitor session** command to capture and forward traffic to an external interface:

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# monitor session 1 source vlan 44 both
Router(config)# monitor session 1 destination interface g9/1
Router(config)# end
Router#
2w0d: %SYS-5-CONFIG_I: Configured from console by console
```

This example shows how to use the **show monitor session** command to display the destination port location:

```
Router# show monitor session 1
Session 1
-----
Source Ports:
  RX Only:      None
  TX Only:      None
  Both:         None
Source VLANs:
  RX Only:      None
  TX Only:      None
  Both:         44
Destination Ports: Gi9/1
Filter VLANs:    None
```

Monitoring Dropped Packets Using show tcam interface Command

The PFC3B, PFC3BXL, PFC3C, and PFC3CXL support ACL hit counters in hardware. You can use the **show tcam interface** command to display each entry in the ACL TCAM.

This example shows how to use the **show tcam interface** command to display the number of times the entry was hit:

```
Router# show tcam interface fa5/2 acl in ip detail
```

```
-----
DPort - Destination Port   SPort - Source Port      TCP-F - U -URG Pro   - Protocol
I      - Inverted LOU      TOS   - TOS Value        - A -ACK rtr   - Router
MRFM   - M -MPLS Packet   TN     - T -Tcp Control      - P -PSH COD   - C -Bank Care Flag
        - R -Recirc. Flag   - N -Non-cachable    - R -RST       - I -OrdIndep. Flag
        - F -Fragment Flag CAP   - Capture Flag      - S -SYN       - D -Dynamic Flag
        - M -More Fragments F-P   - FlowMask-Prior.   - F -FIN T     - V(Value)/M(Mask)/R(Result)
X      - XTAG              (*)    - Bank Priority
-----
```

```
Interface: 1018   label: 1   lookup_type: 0
protocol: IP     packet-type: 0
```

```
++-----++-----++-----++-----++-----++-----++-----++-----++
|T|Index|  Dest Ip Addr | Source Ip Addr|   DPort   |   SPort   | TCP-F|Pro|MRFM|X|TOS|TN|COD|F-P|
++-----++-----++-----++-----++-----++-----++-----++-----++
V 18396      0.0.0.0      0.0.0.0      P=0          P=0          ----- 0 ---- 0  0 -- --- 0-0
M 18404      0.0.0.0      0.0.0.0      0            0            0 ---- 0  0
R rslt: L3_DENY_RESULT          rtr_rslt: L3_DENY_RESULT

V 36828      0.0.0.0      0.0.0.0      P=0          P=0          ----- 0 ---- 0  0 -- --- 0-0
M 36836      0.0.0.0      0.0.0.0      0            0            0 ---- 0  0
R rslt: L3_DENY_RESULT (*)      rtr_rslt: L3_DENY_RESULT (*)
Router#
```

You can also use the TTL and IP options counters to monitor the performance of the Layer 3 forwarding engine.

This example shows how to use the **show mls statistics** command to display packet statistics and errors associated with the Layer 3 forwarding engine:

```
Router# show mls statistics
```

```
Statistics for Earl in Module 6
```

```
L2 Forwarding Engine
  Total packets Switched          : 25583421

L3 Forwarding Engine
  Total packets L3 Switched       : 25433414 @ 24 pps

  Total Packets Bridged           : 937860
  Total Packets FIB Switched      : 23287640
  Total Packets ACL Routed        : 0
  Total Packets Netflow Switched  : 0
  Total Mcast Packets Switched/Routed : 96727
  Total ip packets with TOS changed : 2
  Total ip packets with COS changed : 2
  Total non ip packets COS changed : 0
  Total packets dropped by ACL    : 33
  Total packets dropped by Policing : 0
```



```

Errors
  MAC/IP length inconsistencies      : 0
  Short IP packets received         : 0
  IP header checksum errors         : 0
  TTL failures                      : 0
<----- TTL counters
  MTU failures                      : 0
<-----MTU failure counters

Total packets L3 Switched by all Modules: 25433414 @ 24 pps

```

Monitoring Dropped Packets Using VACL Capture

The VACL capture feature allows you to direct traffic to ports configured to forward captured traffic. The capture action sets the capture bit for the forwarded packets so that ports with the capture function enabled can receive the packets. Only forwarded packets can be captured.

You can use VACL capture to assign traffic from each VLAN to a different interface.

VACL capture does not allow you to send one type of traffic, such as HTTP, to one interface and another type of traffic, such as DNS, to another interface. Also, VACL capture granularity is only applicable to traffic switched locally; you cannot preserve the granularity if you direct traffic to a remote router.

This example shows how to use VACL capture to capture and forward traffic to a local interface:

```

Router(config-if)# switchport capture
Router(config-if)# switchport capture allowed vlan add 100

```

Displaying Rate-Limiter Information

The **show mls rate-limit** command displays information about the configured rate limiters.

The **show mls rate-limit usage** command displays the hardware register that is used by a rate-limiter type. If the register is not used by any rate-limiter type, Free is displayed in the output. If the register is used by a rate-limiter type, Used and the rate-limiter type are displayed.

In the command output, the rate-limit status could be one of the following:

- On indicates that a rate for that particular case has been set.
- Off indicates that the rate-limiter type has not been configured, and the packets for that case are not rate limited.
- High CPU utilization occurs when:
 - CoPP rate limits and drops exceeding traffic
 - **mls qos protocol protocol** pass-through is configured

To avoid this, rely on the CoPP to drop excessive traffic and not **mls qos protocol** to relay traffic directly to route processor.

- On/Sharing indicates that a particular case (not manually configured) is affected by the configuration of another rate limiter belonging to the same sharing group.
- A hyphen indicates that the multicast partial-SC rate limiter is disabled.

In the command output, the rate-limit sharing indicates the following information:

- Whether sharing is static or dynamic
- Group dynamic sharing codes

To display the configured rate limiters, use the **show mls rate-limit** command:

```
Router# show mls rate-limit
Sharing Codes: S - static, D - dynamic
Codes dynamic sharing: H - owner (head) of the group, g - guest of the group
```

Rate Limiter Type	Status	Packets/s	Burst	Sharing
-----	-----	-----	-----	-----
MCAST NON RPF	Off	-	-	-
MCAST DFLT ADJ	On	100000	100	Not sharing
MCAST DIRECT CON	Off	-	-	-
ACL BRIDGED IN	Off	-	-	-
ACL BRIDGED OUT	Off	-	-	-
IP FEATURES	Off	-	-	-
ACL VACL LOG	On	2000	1	Not sharing
CEF RECEIVE	Off	-	-	-
CEF GLEAN	Off	-	-	-
MCAST PARTIAL SC	On	100000	100	Not sharing
IP RPF FAILURE	On	100	10	Group:0 S
TTL FAILURE	Off	-	-	-
ICMP UNREAC. NO-ROUTE	On	100	10	Group:0 S
ICMP UNREAC. ACL-DROP	On	100	10	Group:0 S
ICMP REDIRECT	Off	-	-	-
MTU FAILURE	Off	-	-	-
MCAST IP OPTION	Off	-	-	-
UCAST IP OPTION	Off	-	-	-
LAYER_2 PDU	Off	-	-	-
LAYER_2 PT	Off	-	-	-
IP ERRORS	On	100	10	Group:0 S
CAPTURE PKT	Off	-	-	-
MCAST IGMP	Off	-	-	-
MCAST IPv6 DIRECT CON	Off	-	-	-
MCAST IPv6 *G M BRIDG	Off	-	-	-
MCAST IPv6 *G BRIDGE	Off	-	-	-
MCAST IPv6 SG BRIDGE	Off	-	-	-
MCAST IPv6 ROUTE CNTL	Off	-	-	-
MCAST IPv6 DFLT DROP	Off	-	-	-
MCAST IPv6 SECOND. DR	Off	-	-	-

Router#

To display the usage of the hardware rate limiters, use the **show mls rate-limit usage** command:

```
Router# show mls rate-limit usage
```

	Rate Limiter Type	Packets/s	Burst
-----	-----	-----	-----
Layer3 Rate Limiters:			
RL# 0: Free	-	-	-
RL# 1: Free	-	-	-
RL# 2: Free	-	-	-
RL# 3: Used			
	MCAST DFLT ADJ	100000	100
RL# 4: Free	-	-	-
RL# 5: Free	-	-	-
RL# 6: Used			
	IP RPF FAILURE	100	10
	ICMP UNREAC. NO-ROUTE	100	10
	ICMP UNREAC. ACL-DROP	100	10
	IP ERRORS	100	10
RL# 7: Used			
	ACL VACL LOG	2000	1
RL# 8: Rsvd for capture	-	-	-
Layer2 Rate Limiters:			
RL# 9: Reserved			

```

Router#
      RL#10: Reserved
      RL#11: Free
      RL#12: Free

```

Understanding How Control Plane Policing Works

The control plane policing (CoPP) feature increases security on the Cisco 7600 series router by protecting the MSFC from unnecessary or DoS traffic and giving priority to important control plane and management traffic. The PFC3 and DFC3 provide hardware support for CoPP. CoPP works with the PFC3 rate limiters.

The PFC3 supports the built-in “special case” rate limiters that can be used when an ACL cannot classify particular scenarios, such as IP options cases, TTL and MTU failure cases, packets with errors, and multicast packets. When enabling the special-case rate limiters, the special-case rate limiters override the CoPP policy for packets matching the rate-limiter criteria.

The traffic managed by the MSFC is divided into three functional components or *planes*:

- Data plane
- Management plane
- Control plane

The majority of traffic managed by the MSFC is handled by way of the control and management planes. You can use CoPP to protect the control and management planes, and ensure routing stability, reachability, and packet delivery. CoPP uses a dedicated control plane configuration through the modular QoS CLI (MQC) to provide filtering and rate-limiting capabilities for the control plane packets.

CoPP Default Configuration

CoPP is disabled by default and it is recommended that you enable CoPP. For information on CoPP, see *Control Plane Policing Implementation Best Practices* at http://www.cisco.com/web/about/security/intelligence/coppwp_gs.html#9.

CoPP Configuration Guidelines and Restrictions

When configuring CoPP, follow these guidelines and restrictions:

- Classes that match multicast are not applied in hardware but are applied in software.
- CPP is not supported in hardware for broadcast packets. The combination of ACLs, traffic storm control, and CPP software protection provides protection against broadcast DoS attacks.
- CoPP does not support ARP policies. ARP policing mechanisms provide protection against ARP storms.
- CoPP does not support non-IP classes except for the default non-IP class. ACLs can be used instead of non-IP classes to drop non-IP traffic, and the default non-IP CoPP class can be used to limit to non-IP traffic that reaches the RP CPU.
- Do not use the **log** keyword in CoPP policy ACLs.

- With PFC3A, egress QoS and CoPP cannot be configured at the same time. In this situation, CoPP is performed in the software. A warning message is displayed to inform you that egress QoS and CoPP cannot be configured at the same time.
- If you have a large QoS configuration, the system may run out of TCAM space. If this is the case, CoPP may be performed in software.
- When there is a large QoS configuration for other interfaces, you can run out of TCAM space. When this situation occurs, CoPP may be performed entirely in software and result in performance degradation and CPU cycle consumption.
- You must ensure that the CoPP policy does not filter critical traffic such as routing protocols or interactive access to the routers. Filtering this traffic could prevent remote access to the router, requiring a console connection.
- PFC3 supports built-in special-case rate limiters, which are useful for situations where an ACL cannot be used (for example, TTL, MTU, and IP options). When you enable the special-case rate limiters, you should be aware that the special-case rate limiters will override the CoPP policy for packets matching the rate-limiter criteria.
- CoPP is not enabled in hardware unless MLS QoS is enabled globally with the **mls qos** command. If the **mls qos** command is not entered, CoPP will only work in software and will not provide any benefit to the hardware.
- Neither egress CoPP nor silent mode is supported. CoPP is only supported on ingress (service-policy output CoPP cannot be applied to the control plane interface).
- ACE hit counters in hardware are only for ACL logic. You can rely on software ACE hit counters and the **show access-list**, **show policy-map control-plane**, and **show mls ip qos** commands to troubleshoot evaluate CPU traffic.
- CoPP is performed on a per-forwarding-engine basis and software CoPP is performed on an aggregate basis.
- CoPP is not supported in hardware for multicast packets. The combination of ACLs, multicast CPU rate limiters and CoPP software protection provides protection against multicast DoS attacks.
- CoPP does not support ACEs with the **log** keyword.
- CoPP uses hardware QoS TCAM resources. Enter the **show tcam utilization** command to verify the TCAM utilization.
- When CoPP is configured and a unicast traffic hits the CoPP classification, regardless of trust configured on the input port, packets punted to RP are treated with trust DSCP action. If CoPP is configured, and you want the punted packets marked or trusted based on input port, then execute the **platform ip features sequential** command on the input port. Since multicast and broadcast traffic do not hit the hardware Cpp classification, this behaviour is not applicable to multicast and broadcast traffic.
- When you set the policer value, note that the mls qos protocol is supported and impacts the traffic switch in the router.
- The incoming control packets needs to be trusted for them to be prioritized in control-plane SPD, else they end up competing with other data packets being punted to RP and this increases their probability of getting dropped.
- For packets ingressing on LAN interfaces like 6xxx linecards:
 - If a CoPP is not applied on the router, its preferable that either the ingress traffic DSCP/Precedence is trusted using "mls qos trust" or remarking of the incoming control protocol packets to precedence values lower than precedence-6 is avoided. The control protocol packets could be classified based on their precedence or DSCP value.

- If a CoPP is applied and a unicast traffic hits the CoPP classification, then the CoPP implicitly overrides incoming trust state with trust-dscp and preserves DSCP/Precedence on the packets being punted to control-plane. Multicast and broadcast traffic does not hit the hardware CoPP classification and, hence this is not applicable to multicast or broadcast traffic.
- For packets ingressing on WAN interfaces like Sip400/ES+ linecards
- Avoid remarking the incoming control protocol packets to precedence values lower than precedence-6 or 7. The control protocol packets can be identified based on their precedence or DSCP value.
- High CPU utilization occurs when:
 - CoPP rate limits and drops exceeding traffic
 - **mls qos protocol protocol** pass-through is configured

To avoid this, rely on the CoPP to drop excessive traffic and not **mls qos protocol** to relay traffic directly to route processor.

Configuring CoPP

CoPP uses MQC to define traffic classification criteria and to specify the configurable policy actions for the classified traffic. You must first identify the traffic to be classified by defining a class map. The class map defines packets for a particular traffic class. After you have classified the traffic, you can create policy maps to enforce policy actions for the identified traffic. The **control-plane** global configuration command allows the CoPP service policies to be directly attached to the control plane.

For information on how to define the traffic classification criteria, refer to the [“Personalizing CoPP” section on page 36-23](#).

To configure CoPP, perform this task:

	Command	Purpose
Step 1	Router(config)# mls qos	Enables MLS QoS globally.
Step 2	Router(config)# ip access-list extended <i>access-list-name</i> Router(config-ext-nacl)# { permit deny } <i>protocol source source-wildcard</i> destination destination-wildcard [precedence precedence] [tos tos] [established] [log log-input] [time-range <i>time-range-name</i>] [fragments]	Defines ACLs to match traffic: <ul style="list-style-type: none"> • permit sets the conditions under which a packet passes a named IP access list. • deny sets the conditions under which a packet does not pass a named IP access list. Note You must configure ACLs in most cases to identify the important or unimportant traffic.
Step 3	Router(config)# class-map <i>traffic-class-name</i> Router(config-cmap)# match { ip precedence } { ip dscp } <i>access-group</i>	Defines the packet classification criteria. Use the match statements to identify the traffic associated with the class.

	Command	Purpose
Step 4	Router(config)# policy-map <i>service-policy-name</i> Router(config-pmap)# class <i>traffic-class-name</i> Router(config-pmap-c)# police { <i>bits-per-second</i> [<i>normal-burst-bytes</i>] [<i>maximum-burst-bytes</i>] [pir <i>peak-rate-bps</i>]} [conform-action <i>action</i>] [exceed-action <i>action</i>] [violate-action <i>action</i>]	Defines a service policy map. Use the class <i>traffic-class-name</i> command to associate classes to the service policy map. Use the police statements to associate actions to the service policy map.
Step 5	Router(config)# control-plane Router(config-cp)#	Enters the control plane configuration mode.
Step 6	Router(config-cp)# service-policy input <i>service-policy-name</i>	Applies the QoS service policy to the control plane.

When defining the packet classification criteria, follow these guidelines and restrictions:

- To avoid matching the filtering and policing that are configured in a subsequent class, configure policing in each class. CoPP does not apply the filtering in a class that does not contain a police command. A class without a police command matches no traffic.
- The ACLs used for classification are QoS ACLs. QoS ACLs supported are IP standard, extended, and named (IPv6 ACLs are not supported in hardware).
- These are the only match types supported:
 - **ip precedence**
 - **ip dscp**
 - **access-group**
- Only IP ACLs are supported in hardware.
- MAC-based matching is done in software only.
- You can enter one **match** command in a single class map only.

When defining the service policy, the **police** policy-map action is the only supported action.

When applying the service policy to the control plane, the **input** direction is only supported.

Monitoring CoPP

You can enter the **show policy-map control-plane** command for developing site-specific policies, monitoring statistics for the control plane policy, and troubleshooting CoPP. This command displays dynamic information about the actual policy applied, including rate information and the number of bytes (and packets) that conformed or exceeded the configured policies both in hardware and in software.

The output of the **show policy-map control-plane** command is as follows:

```
Router# show policy-map control-plane
Control Plane Interface
  Service policy CoPP-normal
Hardware Counters:
class-map: CoPP-normal (match-all)
  Match: access-group 130
  police :
    96000 bps 3000 limit 3000 extended limit
Earl in slot 3 :
  0 bytes
```

```

5 minute offered rate 0 bps
aggregate-forwarded 0 bytes action: transmit
exceeded 0 bytes action: drop
aggregate-forward 0 bps exceed 0 bps
Earl in slot 5 :
0 bytes
5 minute offered rate 0 bps
aggregate-forwarded 0 bytes action: transmit
exceeded 0 bytes action: drop
aggregate-forward 0 bps exceed 0 bps

```

Software Counters:

```

Class-map: CoPP-normal (match-all) 0 packets, 0 bytes
  5 minute offered rate 0 bps, drop rate 0 bps
  Match: access-group 130
  police:
    96000 bps, 3125 limit, 3125 extended limit
    conformed 0 packets, 0 bytes; action: transmit
    exceeded 0 packets, 0 bytes; action: drop
    conformed 0 bps, exceed 0 bps, violate 0 bps

```

Router#

To display the hardware counters for bytes dropped and forwarded by the policy, enter the **show mls qos ip** command:

Router# **show mls qos ip**

QoS Summary [IP]: (* - shared aggregates, Mod - switch module)

Int	Mod	Dir	Class-map	DSCP	Agg Id	Trust Fl Id	AgForward-By	AgPoliced-By
CPP	5	In	CoPP-normal	0	1	dscp 0	505408	83822272
CPP	9	In	CoPP-normal	0	4	dscp 0	0	0

Router#

To display the CoPP access list information, enter the **show access-lists coppacl-bgp** command:

Router#**show access-lists coppacl-bgp**

Extended IP access list coppacl-bgp

10 permit tcp host 47.1.1.1 host 10.9.9.9 eq bgp (4 matches)

20 permit tcp host 47.1.1.1 eq bgp host 10.9.9.9

30 permit tcp host 10.86.183.120 host 10.9.9.9 eq bgp (1 match)

40 permit tcp host 10.86.183.120 eq bgp host 10.9.9.9

Personalizing CoPP

CoPP policy applied on a router should be personalized to best fit the router traffic profile getting punted to RP. Personalizing ensures that:

- The right kind of traffic is prioritized over other less priority non priority traffic
- Stabilizes the network
- Achieves control plane protection
- Understand if any traffic is missed in the classification

To personalize the policy, use the Mini Protocol Analyzer tool to analyze the traffic punted to RP. This tool helps you capture traffic being punted to RP and check what is the rate at which it is being punted. The data obtained can be used to identify the classes and police rates required to set up CoPP. For more information on the Mini Protocol Analyzer tool, see [Chapter 56, “Using the Mini Protocol Analyzer”](#).

Developing a CoPP Policy

Prior to developing a CoPP policy, a required volume of traffic must be identified and separated into different classes. Stratifying traffic into distinct groups based on relative importance is the recommended method:

Here are the sample classification criteria used when developing CoPP policer:

- Do not use any policer in class-default. All the potential traffic should be classified in a specific class rather than in class-default.
- For catch-all traffic, use the **match ipv4/ipv6 any class** command. Though class-default serves the same purpose, we recommend you to minimize the traffic with class-default action as shown in this example:

```
Policy-map CoPP
```

```
  Class CLASS1
```

```
    Police <>
```

```
  Class CLASS2
```

```
    Police <>
```

```
  Class MATCH-IPv4-ANY Match all IPv4 traffic which doesn't fall in any of the above mentioned classes
```

```
    Police <>
```

```
  Class MATCH-IPv6-ANY Match all IPV6 traffic which doesn't fall in any of the above mentioned classes
```

```
    Police <>
```

In the section [Example Of a CoPP Policy, page 36-27](#), traffic is grouped into five different classes. The actual number of classes differs and should be selected based on local requirements and security policies. These traffic classes are defined with regard to the CPU or control plane.

The five different classes are:

- Critical
 - Traffic that is crucial to the operation of the router and the network
 - Examples: routing protocols like Border Gateway Protocol (BGP)
 - Some sites might choose to classify traffic other than the ones crucial to the operation as critical when appropriate
- Important
 - Frequently used traffic that is necessary for day-to-day operations
 - Examples: traffic used for remote network access and management (telnet, Secure Shell (SSH), Network Time Protocol (NTP) and Simple Network Management Protocol (SNMP))
- Normal
 - Traffic that is functional but not essential to network operation
 - Normal traffic used to be particularly hard to address when designing control-plane protection schemes, as it should be permitted but should never pose a risk to the router. With CoPP, this traffic is permitted, but limited to a low rate.
 - Examples: ICMP echo request
- Undesirable

- Explicitly identifies “bad” or malicious traffic that should be dropped and denied access to the Route Processor
 - Particularly useful when known traffic destined to the router should always be denied and not placed into a default category. Explicitly denying traffic allows the end-user to collect rough statistics on this traffic using the **show** commands and therefore offers some insight into the rate of denied traffic.
- Layer 2 class
 - Traffic used for address resolution protocol (ARP). Excessive ARP packets can potentially monopolize MSFC resources, depriving other important processes of resources; CoPP can be used to rate limit ARP packets to prevent this situation. Currently, ARP is the only Layer 2 protocol specifically classified using the match protocol classification criteria.
- Match-Any class
 - Matches all the other IPv4/IPv6 traffic (which doesn’t fall into any of the above class), and police them as appropriate. It is primarily designed so that the class-default doesn’t need a policer.
- Default
 - The remaining traffic destined to the Route Processor and has not been identified
 - A default classification helps monitoring of statistics to determine the rate of unidentified traffic destined to the control-plane. The identified traffic can be further analyzed to classify and if needed updated with the other CoPP policy entries
 - The Sup720 in Release 12.2(18)SXD1 does not support the MQC “class-default” in hardware. The support has been added effective Release 12.2(18)SXE1 software release. Anyway, this is not a big limitation as shown in the example below, where the “class-default” is replaced by a normal class-map.
 - Certain traffic types, namely Layer 2 keepalives, CLNS, and other non-IP packets will be seen by a CoPP (only in class-default). These traffic types cannot be classified by MQC for CoPP and hence, will always fall into the aCoPP class-default class. If aCoPP is configured, it is best practice to never rate limiting class-default so that Layer 2 keepalives and other essential control plane traffic are not dropped. This is the primary reason for always configuring a “catch all” IP class in the CoPP policy-map just prior to class-default.

Using the classification scheme defined above, commonly used traffic is identified with a series of ACLs:

- Class CoPP-CRITICAL : ACL 120: critical traffic
- Class CoPP-IMPORTANT: ACL 121: important traffic
- Class CoPP-NORMAL : ACL 122: normal traffic
- Class CoPP-UNWANTED ACL 123: explicitly denies unwanted traffic (For example, slammer worm traffic)
- Class CoPP-ARP : Match the ARP protocol
- Class CoPP-Match-all ACL 124: the rest of the traffic

The ACLs build classes of traffic that are used to define the policies.

Sample CoPP Policy

This is an example of a CoPP policy developed using the ACLs above:

```
access-list 120 remark *** ACL for CoPP-Critical ***
access-list 120 remark *** LDP ***
access-list 120 permit udp 172.0.0.0 0.0.255.255 eq 646 any
access-list 120 permit udp 172.0.0.0 0.0.255.255 any eq 646
access-list 120 permit tcp 172.0.0.0 0.0.255.255 eq 646 any
access-list 120 permit tcp 172.0.0.0 0.0.255.255 any eq 646
access-list 120 remark *** BGP ***
access-list 120 permit tcp 172.0.0.0 0.0.255.255 eq bgp any
access-list 120 permit tcp 172.0.0.0 0.0.255.255 any eq bgp
access-list 120 remark *** PIM ***
access-list 120 permit pim 172.0.0.0 0.0.255.255 any
access-list 120 permit pim any 172.0.0.0 0.0.255.255
access-list 121 remark *** ACL for CoPP-IMPORTANT
access-list 121 remark *** Telnet ***
access-list 121 permit tcp 172.0.0.0 0.0.255.255 172.0.0.0 0.0.255.255 eq telnet
access-list 121 remark *** SSH ***
access-list 121 permit tcp 172.0.0.0 0.0.255.255 152.0.0.0 0.255.255.255 eq 22
access-list 121 remark *** SNMP ***
access-list 121 permit udp 172.0.0.0 0.0.255.255 152.0.0.0 0.255.255.255 eq snmp
access-list 121 remark *** NTP ***
access-list 121 permit udp 172.0.0.0 0.0.255.255 host 192.168.70.10 eq ntp
access-list 121 permit udp 172.0.0.0 0.0.255.255 host 192.168.70.30 eq ntp
access-list 121 remark *** Syslog ***
access-list 121 permit udp 172.0.0.0 0.0.255.255 152.0.0.0 0.255.255.255 eq syslog
access-list 121 remark *** TACAS+ ***
access-list 121 permit tcp 172.0.0.0 0.0.255.255 152.0.0.0 0.255.255.255 eq tacacs
access-list 122 remark CoPP normal traffic
access-list 122 permit icmp any any ttl-exceeded
access-list 122 permit icmp any any port-unreachable

access-list 122 permit icmp any any echo-reply
access-list 122 permit icmp any any echo

access-list 123 remark *** ACL for CoPP-UNDESIRABLE
access-list 123 permit icmp any any fragments
access-list 123 permit udp any any fragments
access-list 123 permit tcp any any fragments
access-list 123 permit ip any any fragments
access-list 124 remark *** ACL for CoPP-Match-all
access-list 124 permit ip any any
access-list 124 permit ipv6 any any

class-map match-all CoPP-CRITICAL
```

```

match access-group 120
class-map match-all CoPP-IMPORTANT
match access-group 121
class-map match-all CoPP-NORMAL
match access-group 122
class-map match-all CoPP-ARP
match protocol ARP
class-map match-all CoPP-UNWANTED
match access-group 123
class-map match-all CoPP-Match-all
match access-group 124

```

Although rate limiting punted traffic is recommended, ensure that the required rates of traffic are well understood, particularly for critical traffic. A very low rate might discard or drop necessary traffic, whereas a very high rate might inundate the Route Processor with non-critical packets to process. These rates are site-specific and vary depending on the local topology and routing table size.

The policed rate depends on both determined criticality and site-specific rate values. For instance, the “normal” SNMP rates differ based on environment. Using the classification scheme mentioned above, critical traffic is permitted without limitation, while important, normal, and default traffic are permitted with appropriate rate limiting. However, this deployment causes the network to drop undesirable traffic immediately.

[Table 36-3](#) extends this example and summarizes a sample policy. Note that the rates defined in the table are used for illustrative purposes; every environment contains different baselines. For example, a large Service Provider topology would require a higher rate of critical traffic (due to large BGP routing tables) than would a typical enterprise network.

The purpose of defining the critical traffic class is not limit rates, but tag this traffic as critical and provide it with unconditional access to the Route Processor. As the policy becomes increasingly refined, a more representative rate should be used for critical traffic and **show** commands can detect abnormal increases in traffic rates.

Table 36-3 **Sample CoPP Policy**

Traffic class	Rate (bps)	Conform action	Exceed action
Critical	N/A	Transmit	Transmit
Important	125,000	Transmit	Drop
Normal	64,000	Transmit	Drop
Undesirable	32,000	Drop	Drop
ARP	64,000	Transmit	Drop
MATCH-ALL	96000	Transmit	Drop
Class-default	-	-	-

Example Of a CoPP Policy

```

policy-map CoPP
class CoPP-CRITICAL
police 1000000 31250 31250 conform-action transmit exceed-action transmit violate-action
transmit
class CoPP-IMPORTANT

```

```

police 128000 4000 4000 conform-action transmit exceed-action drop violate-action drop
class CoPP-NORMAL
police 64000 2000 2000 conform-action transmit exceed-action drop violate-action drop
class CoPP-UNDESIRABLE
police 32000 1500 1500 conform-action transmit exceed-action drop violate-action drop
class CoPP-ARP
police 64000 1500 1500 conform-action transmit exceed-action drop violate-action drop
class CoPP-Match-all
police 96000 3000 3000 conform-action transmit exceed-action drop violate-action drop
class class-default

```

Configuring Sticky ARP

Sticky ARP prevents MAC address spoofing by ensuring that ARP entries (IP address, MAC address, and source VLAN) do not get overridden. The router maintains ARP entries in order to forward traffic to end devices or other routers. ARP entries are usually updated periodically or modified when ARP broadcasts are received. During an attack, ARP broadcasts are sent using a spoofed MAC address (with a legitimate IP address) so that the router learns the legitimate IP address with the spoofed MAC address and begins to forward traffic to that MAC address. With sticky ARP enabled, the router learns the ARP entries and does not accept modifications received through ARP broadcasts. If you attempt to override the sticky ARP configuration, you will receive an error message. For a complete description of the system error messages, refer to the *Cisco 7600 Series Router Cisco IOS System Message Guide* at this URL:

<http://www.cisco.com/univercd/cc/td/doc/product/core/cis7600/software/122sr/msggd/index.htm>

To configure sticky ARP on a Layer 3 interface, perform the following task:

	Command	Purpose
Step 1	Router(config)# interface <i>type</i> ¹ <i>slot/port</i>	Selects the interface on which sticky ARP is applied.
Step 2	Router(config-if)# ip sticky-arp	Enables sticky ARP.
	Router(config-if)# no ip sticky-arp ignore	Removes the previously configured sticky ARP command.
Step 3	Router(config-if)# ip sticky-arp ignore	Disables sticky ARP.

1. *type* = ethernet, fastethernet, gigabitethernet, or tengigabitethernet

This example shows how to enable sticky ARP on interface 5/1:

```

Router# configure terminal
Router(config)# interface gigabitethernet 5/1
Router(config-if)# ip sticky-arp
Router(config-if)# end
Router#

```