CHAPTER 27

Configuring Denial of Service Protection

This chapter contains information on how to protect your Cisco ME 6500 series Ethernet switch against Denial of Service (DoS) attacks. The information covered in this chapter is unique to the Cisco ME 6500 series Ethernet switches, 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/univercd/cc/td/doc/product/software/ios122/122cgcr/fsecur_c/index.htm

- *Cisco IOS Security Command Reference*, Release 12.2, at this URL:

  http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fsecur_r/index.htm

Note For complete syntax and usage information for the commands used in this chapter, refer to these publications:

- The *Cisco ME 6500 Series Ethernet Switch Cisco IOS Command Reference*, Release 12.2ZU at this URL:

  http://lbj/push_targets1/ucdit/cc/td/doc/product/metro/me6500/122zu/cr/index.htm

- The Release 12.2 publications at this URL:

  http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/index.htm

This chapter consists of these sections:

Understanding How DoS Protection Works

This section contains information about the available methods to counteract DoS attacks on the Cisco ME 6500 series Ethernet switch and includes configuration examples. The Cisco ME 6500 series Ethernet switch 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 27-17.

These sections describe DoS protection on the Cisco ME 6500 series Ethernet switch:

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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 switch interface that is pointing to the Internet. You can apply an inbound ACL on the switch 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 switch interface, it matches on that ACL and drops the packet before it causes damage.

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 ME 6500 series Ethernet switches.

QoS Rate Limiting

QoS ACLs limit the amount of a particular type of traffic that is processed by the MSFC2A. If a DoS attack is initiated against the MSFC2A, QoS ACLs can prevent the DoS traffic from reaching the MSFC2A data path and congesting it. The PFC3C performs QoS in hardware, which offers an efficient means of limiting DoS traffic (once that traffic has been identified) to protect the switch from impacting the MSFC2A.

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 MSFC2A 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 PFC3C.

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 PFC3C 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 in the PFC3C is supported in hardware. All packets that fail the uRPF check, and are forwarded because of an applied ACL, can be sent and rate limited to the MSFC2A 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 Gigabit Ethernet 1/3 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 ME 6500 series Ethernet switch 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 MSFC2A 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.

ARP Policing

During an attack, malicious users may try to overwhelm the MSFC2A 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 configurable 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 MSFC2A CPU against attacks such as line-rate ARP attacks, it does not only police routing protocols and ARP packets to the switch 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)
```

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 ME 6500 series Ethernet switch, reduces the need for redirects.
- Disable unreachables because a platform that supports hardware unreachables, such as the Cisco ME 6500 series Ethernet switch, reduces the need for unreachables.
- 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.

Hardware-Based Rate Limiters on the PFC3C

The Cisco ME 6500 series Ethernet switches supports additional hardware-based rate limiters. The forwarding engine provides eight rate-limiter registers for the new rate limiters, which are configured globally on the switch. These rate-limiter registers are present in the PFC3C (also called the Layer 3 forwarding engine) 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 Layer 3 forwarding engine only, 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 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

Ingress-Egress ACL Bridged Packets (Unicast Only)

This rate limiter rate limits packets sent to the MSFC2A because of an ingress/egress ACL bridge result. The switch accomplishes this by altering existing and new ACL TCAM entries with a TCAM bridge result to a Layer 3 redirect result pointing to the MSFC2A. 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 switch 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 MSFC2A 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 MSFC2A. The uRPF check rate limiters allow you to rate limit the packets per second that are bridged to the MSFC2A CPU when a uRPF check failure occurs.

This example shows how to rate limit the uRPF check failure packets sent to the MSFC2A 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 MSFC2A 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.

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 MSFC2A). The ICMP unreachable rate limiter allows you to rate limit the packets that are sent to the MSFC2A containing unreachable addresses.

This example shows how to rate limit the packets that are sent to the MSFC2A 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 MSFC2A 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 MSFC2A. This situation occurs when traffic enters a port and contains the destination of a host on a subnet that is locally connected to the MSFC2A, 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 MSFC2A 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 MSFC2A 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 MSFC2A. For these security features, you need to rate limit the number of these packets being sent to the MSFC2A 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 switch 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 MSFC2A may be overwhelmed. Rate limiting would be advantageous in this situation.

IPSec and inspection are also done by the MSFC2A 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 MSFC2A 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 switch, the MSFC2A sends ICMP-redirect messages to the host to correct its sending path. If this traffic occurs continuously, and is not rate limited, the MSFC2A 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 MSFC2A 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 MSFC2A does the logging. When VACL logging is configured on the switch, 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 vacl-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 MSFC2A CPU. This might cause the MSFC2A to be overwhelmed.

This example shows how to rate limit packets failing the MTU failures from being sent to the MSFC2A 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 PFC3C. IGMP snooping listens to IGMP messages between the hosts and the PFC3C. 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 PFC3C and not the MSFC2A CPU. 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 PFC3C. 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). 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 l2pt 10000 10
```

IP Errors

This rate limiter limits the packets with IP checksum and length errors. When a packet reaches the PFC3C with an IP checksum error or a length inconsistency error, it must be sent to the MSFC2A 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 MSFC2A 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 MSFC2A 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 MSFC2A. For this reason, it may be desirable to rate limit the flow destined to the MSFC2A 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
```

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
```

DoS Protection Default Configuration

Table 27-1 shows the DoS protection default configuration for the PFC3C hardware-based rate limiters.

Table 27-1 PFC3C 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	
Multicast Non-RPF	OFF	

DoS Protection Configuration Guidelines and Restrictions

The section contains these configuration guidelines and restrictions:

Note For the CoPP guidelines and restrictions, see the "CoPP Configuration Guidelines and Restrictions" section on page 27-17.

- 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

Because the rate-limiting method allows a certain number of packets to be forwarded for software processing, you can view the packet drop statistics by entering NetFlow **show** commands from the CLI. You can also 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.

Monitoring Dropped Packets Using NetFlow Commands

The following NetFlow commands display flows that are destined to the switch MAC that are either hardware switched or forwarded to the MSFC2A.

Statistics that are based on source or flow can be displayed only if the MLS NetFlow flow mask is set to a value that is greater than destination-only.

```
Router# show mls ip
Displaying Netflow entries in Supervisor Earl
DstIP           SrcIP           Prot:SrcPort:DstPort  Src i/f:AdjPtr
--------------------------------------------------------------------
200.2.5.3       0.0.0.0         0    :0       :0        0  : 0

Pkts         Bytes       Age   LastSeen  Attributes
```

```
---------------------------------------------------
0            0           1     01:52:25   L3 - Dynamic

Router# show mls netflow flowmask
 current ip flowmask for unicast: destination only
 current ipx flowmask for unicast: destination only

Router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# mls flow ip destination-source
Router(config)# exit
1w6d: %SYS-5-CONFIG_I: Configured from console by console
Router# show mls ip
Displaying Netflow entries in Supervisor Earl
DstIP           SrcIP           Prot:SrcPort:DstPort  Src i/f:AdjPtr
--------------------------------------------------------------------
200.2.5.3       223.255.254.226 0   :0      :0        0      : 0
Pkts         Bytes       Age   LastSeen  Attributes
---------------------------------------------------
0            0           2     01:54:05   L3 - Dynamic

Router#
```

When you use the **show mls ip** command to display information about flows for a specific source or destination address, the command accepts 32-bit prefixes only. When you use the output modifiers, you might see all flows from a specific subnet.

```
Router# show mls ip source 9.9.9.2 module 1
Displaying Netflow entries in module 1
DstIP           SrcIP           Prot:SrcPort:DstPort  Src i/f:AdjPtr
--------------------------------------------------------------------
9.9.9.177       9.9.9.2         0   :0      :0        0      : 0
Pkts         Bytes       Age   LastSeen  Attributes
---------------------------------------------------
0            0           28    01:56:59   L3 - Dynamic

Router# show mls ip mod 4 | include 9.9.9
9.9.9.177       9.9.9.2         0   :0      :0        0   : 0
9.9.9.177       9.9.9.1         0   :0      :0        0   : 0
```

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 gigabitethernet 1/1
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: Gi1/1
Filter VLANs:      None
```

Monitoring Dropped Packets Using show tcam interface Command

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 gigabitethernet 1/2 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 1

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 switch.

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.
- 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
             RL#10: Reserved
             RL#11: Free                       -           -       -
             RL#12: Free                       -           -       -
Router#
```

Understanding How Control Plane Policing Works

The control plane policing (CoPP) feature increases security on the Cisco ME 6500 series Ethernet switch by protecting the MSFC2A from unnecessary or DoS traffic and giving priority to important control plane and management traffic. The PFC3C provides hardware support for CoPP. CoPP works with the PFC3C rate limiters.

The switch 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 MSFC2A is divided into three functional components or *planes*:

- Data plane
- Management plane
- Control plane

The majority of traffic managed by the MSFC2A 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.

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.
- 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 switches. Filtering this traffic could prevent remote access to the switch, requiring a console connection.

- The switch 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 MMLS 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.

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 "Defining Traffic Classification" section on page 27-20.

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`** *`access-list-name`*
	`Router(config-ext-nacl)# {`**`permit`**` | `**`deny`**`}` *`protocol`* **`source`** *`source-wildcard`* **`destination`** *`destination-wildcard`* `[`**`precedence`** *`precedence`*`] [`**`tos`** *`tos`*`] [`**`established`**`] [`**`log`**` | `**`log-input`**`] [`**`time-range`** *`time-range-name`*`] [`**`fragments`**`]`
		Defines ACLs to match traffic:
		• **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`** *`traffic-class-name`*
	`Router(config-cmap)#` **`match`** `{`**`ip precedence`**`} |{`**`ip dscp`**`} |` *`access-group`*
		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** *service-policy-name* Router(config-pmap)# **class** *traffic-class-name* Router(config-pmap-c)# **police** {*bits-per-second* [*normal-burst-bytes*] [*maximum-burst-bytes*] [**pir** *peak-rate-bps*]} | [**conform-action** *action*] [**exceed-action** *action*] [**violate-action** *action*]	Defines a service policy map. Use the **class** *traffic-class-name* 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** *service-policy-name*	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.
- 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 1 :
        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  Trust Fl   AgForward-By   AgPoliced-By
                             Id         Id
-------------------------------------------------------------------------------
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
```

Defining Traffic Classification

The following sections contain information on how to classify CoPP traffic:

- Traffic Classification Overview, page 27-20
- Traffic Classification Guidelines, page 27-22
- Sample Basic ACLs for CoPP Traffic Classification, page 27-22

Traffic Classification Overview

You can define any number of classes, but typically traffic is grouped into classes that are based on relative importance. The following provides a sample grouping:

- Border Gateway Protocol (BGP)—Traffic that is crucial to maintaining neighbor relationships for BGP routing protocol, for example, BGP keepalives and routing updates. Maintaining BGP routing protocol is crucial to maintaining connectivity within a network or to a service provider. Sites that do not run BGP do not need to use this class.

- Interior Gateway Protocol (IGP)—Traffic that is crucial to maintaining IGP routing protocols, for example, open shortest path first OSPF, enhanced interior gateway routing protocol (EIGRP), and routing information protocol (RIP). Maintaining IGP routing protocols is crucial to maintaining connectivity within a network.
- Management—Necessary, frequently used traffic that is required during day-to-day operations. For example, traffic used for remote network access, and Cisco IOS image upgrades and management, such as telnet, secure shell (SSH), network time protocol (NTP), simple network management protocol (SNMP), terminal access controller access control system (TACACS), hypertext transfer protocol (HTTP), trivial file transfer protocol (TFTP), and file transfer protocol (FTP).
- Reporting—Traffic used for generating network performance statistics for the purpose of reporting. For example, using Cisco IOS IP service level agreements (SLAs) to generate ICMP with different DSCP settings in order to report on response times within different QoS data classes.
- Monitoring—Traffic used for monitoring a switch. Traffic should be permitted but should never pose a risk to the switch; with CoPP, this traffic can be permitted but limited to a low rate. For example, ICMP echo request (ping) and traceroute.
- Critical Applications—Critical application traffic that is specific and crucial to a particular customer environment. Traffic included in this class should be tailored specifically to the required application requirements of the user (in other words, one customer may use multicast, while another uses IPSec or generic routing encapsulation (GRE). For example, GRE, hot standby router protocol (HSRP), virtual router redundancy protocol (VRRP), session initiation protocol (SIP), data link switching (DLSw), dynamic host configuration protocol (DHCP), multicast source discovery protocol (MSDP), Internet group management protocol (IGMP), protocol independent multicast (PIM), multicast traffic, and IPsec.
- Layer 2 Protocols—Traffic used for address resolution protocol (ARP). Excessive ARP packets can potentially monopolize MSFC2A resources, starving other important processes; CoPP can be used to rate limit ARP packets to prevent this situation. Currently, ARP is the only Layer 2 protocol that can be specifically classified using the match protocol classification criteria.
- Undesirable—Explicitly identifies bad or malicious traffic that should be unconditionally dropped and denied access to the MSFC2A.The undesirable classification is particularly useful when known traffic destined for the switch should always be denied and not placed into a default category. If you explicitly deny traffic, then you can enter **show** commands to collect approximate statistics on the denied traffic and estimate its rate.
- Default—All remaining traffic destined for the MSFC2A that has not been identified. MQC provides the default class, so the user can specify the treatment to be applied to traffic not explicitly identified in the other user-defined classes. This traffic has a highly reduced rate of access to the MSFC2A. With a default classification in place, statistics can be monitored to determine the rate of otherwise unidentified traffic destined for the control plane. After this traffic is identified, further analysis can be performed to classify it and, if needed, the other CoPP policy entries can be updated to accomodate this traffic.

After you have classified the traffic, the ACLs build the classes of traffic that are used to define the policies. For sample basic ACLs for CoPP classification, see the "Sample Basic ACLs for CoPP Traffic Classification" section on page 27-22.

Traffic Classification Guidelines

When defining traffic classification, follow these guidelines and restrictions:

- Before you develop the actual CoPP policy, you must identify and separate the required traffic into different classes. Traffic is grouped into nine classes that are based on relative importance. The actual number of classes needed might differ and should be selected based on your local requirements and security policies.
- You do not have to define policies that match bidirectionally. You only need to identify traffic unidirectionally (from the network to the MSFC2A) since the policy is applied on ingress only.

Sample Basic ACLs for CoPP Traffic Classification

This section shows sample basic ACLs for CoPP classification. In the samples, the commonly required traffic is identified with these ACLs:

- ACL 120—Critical traffic
- ACL 121—Important traffic
- ACL 122—Normal traffic
- ACL 123—Explicitly denies unwanted traffic
- ACL 124—All other traffic

This example shows how to define ACL 120 for critical traffic:

```
Router(config)# access-list 120 remark CoPP ACL for critical traffic
```

This example shows how to allow BGP from a known peer to this switch's BGP TCP port:

```
Router(config)# access-list 120 permit tcp host 47.1.1.1 host 10.9.9.9 eq bgp
```

This example shows how to allow BGP from a peer's BGP port to this switch:

```
Router(config)# access-list 120 permit tcp host 47.1.1.1 eq bgp host 10.9.9.9
Router(config)# access-list 120 permit tcp host 10.86.183.120 host 10.9.9.9 eq bgp
Router(config)# access-list 120 permit tcp host 10.86.183.120 eq bgp host 10.9.9.9
```

This example shows how to define ACL 121 for the important class:

```
Router(config)# access-list 121 remark CoPP Important traffic
```

This example shows how to permit return traffic from TACACS host:

```
Router(config)# access-list 121 permit tcp host 1.1.1.1 host 10.9.9.9 established
```

This example shows how to permit SSH access to the switch from a subnet:

```
Router(config)# access-list 121 permit tcp 10.0.0.0 0.0.0.255 host 10.9.9.9 eq 22
```

This example shows how to allow full access for Telnet to the switch from a host in a specific subnet and police the rest of the subnet:

```
Router(config)# access-list 121 deny tcp host 10.86.183.3 any eq telnet
Router(config)# access-list 121 permit tcp 10.86.183.0 0.0.0.255 any eq telnet
```

This example shows how to allow SNMP access from the NMS host to the switch:

```
Router(config)# access-list 121 permit udp host 1.1.1.2 host 10.9.9.9 eq snmp
```

This example shows how to allow the switch to receive NTP packets from a known clock source:

```
Router(config)# access-list 121 permit udp host 1.1.1.3 host 10.9.9.9 eq ntp
```

This example shows how to define ACL 122 for the normal traffic class:

```
Router(config)# access-list 122 remark CoPP normal traffic
```

This example shows how to permit switch-originated traceroute traffic:

```
Router(config)# access-list 122 permit icmp any any ttl-exceeded
Router(config)# access-list 122 permit icmp any any port-unreachable
```

This example shows how to permit receipt of responses to the switch that originated the pings:

```
Router(config)# access-list 122 permit icmp any any echo-reply
```

This example shows how to allow pings to the switch:

```
Router(config)# access-list 122 permit icmp any any echo
```

This example shows how to define ACL 123 for the undesirable class.

```
Router(config)# access-list 123 remark explicitly defined "undesirable" traffic
```

Note In the following example, ACL 123 is a permit entry for classification and monitoring purposes, and traffic is dropped as a result of the CoPP policy.

This example shows how to permit all traffic destined to UDP 1434 for policing:

```
Router(config)# access-list 123 permit udp any any eq 1434
```

This example shows how to define ACL 124 for all other traffic:

```
Router(config)# access-list 124 remark rest of the IP traffic for CoPP
Router(config)# access-list 124 permit ip any any
```

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 switch maintains ARP entries in order to forward traffic to end devices or other switchs. 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 switch learns the legitimate IP address with the spoofed MAC address and begins to forward traffic to that MAC address. With sticky ARP enabled, the switch 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.

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

	Command	Purpose
Step 1	`Router(config)#` **`interface gigabitethernet 1//`***`port`*	Selects the interface on which sticky ARP is applied.

	Command	Purpose
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.
	`Router(config-if)# ip sticky-arp ignore`	Disables sticky ARP.

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#
```