Implementing Access Lists

Understanding Access Lists

Access lists perform packet filtering to control which packets move through the network and where. Such controls help to limit network traffic and restrict the access of users and devices to the network. Access lists have many uses, and therefore many commands accept a reference to an access list in their command syntax. Access lists can be used to do the following:

An access control list (ACL) consists of one or more access control entries (ACE) that collectively define the network traffic profile. Access control entries (ACE) are entries in an ACL that describe the access rights related to a particular security identifier or user. This profile can then be referenced by Cisco IOS XR software features such as traffic filtering, route filtering, QoS classification, and access control. There are 2 types of ACLs:

- Standard ACLs- Verifies only the source IP address of the packets. Traffic is controlled by the comparison of the address or prefix configured in the ACL, with the source address found in the packet.
- Extended ACLs- Verifies more than just the source address of the packets. Attributes such as destination address, specific IP protocols, User Datagram Protocol (UDP) or Transmission Control Protocol (TCP) port numbers, Differentiated Services Code Point (DSCP), and so on are validated. Traffic is controlled by a comparison of the attributes stated in the ACL with those in the incoming or outgoing packets.

Cisco IOS XR does not differentiate between standard and extended access lists. Standard access list support is provided for backward compatibility.

Purpose of IP Access Lists

- Filter incoming or outgoing packets on an interface.
- Filter packets for mirroring.
- Redirect traffic as required.
- Restrict the contents of routing updates.
- Limit debug output based on an address or protocol.
- Control vty access.
- Identify or classify traffic for advanced features, such as congestion avoidance, congestion management, and priority and custom queueing.

How an IP Access List Works

An access list is a sequential list consisting of permit and deny statements that apply to IP addresses and possibly upper-layer IP protocols. The access list has a name by which it is referenced. Many software commands accept an access list as part of their syntax.

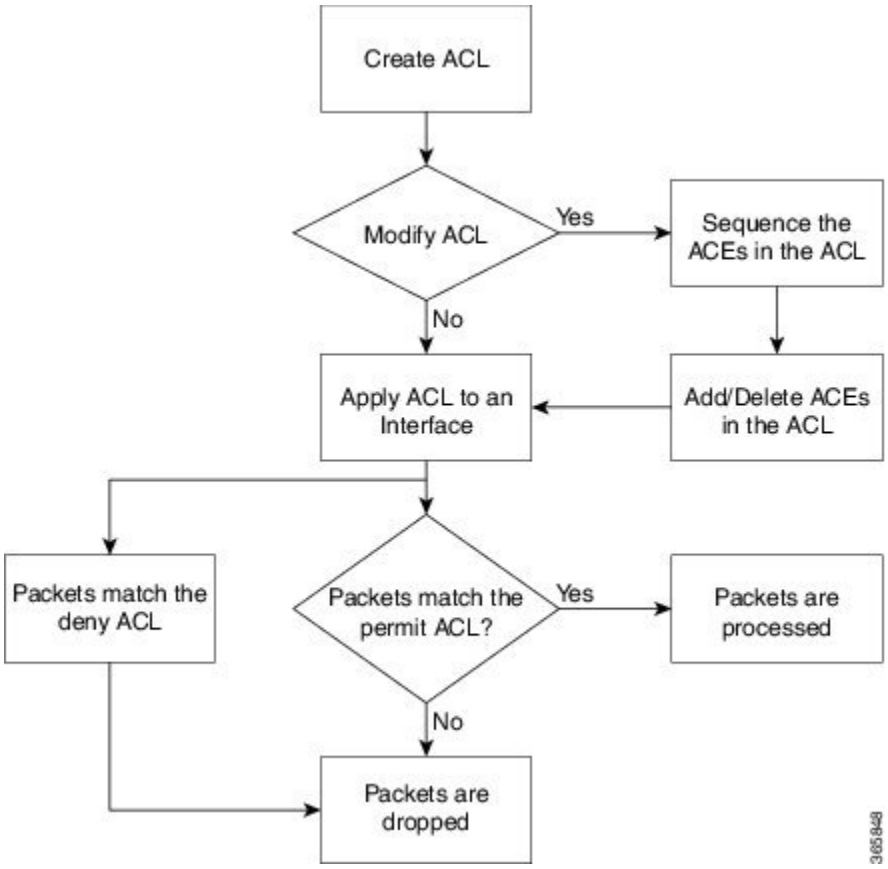
An access list can be configured and named, but it is not in effect until the access list is referenced by a command that accepts an access list. Multiple commands can reference the same access list. An access list can control traffic arriving at the router or leaving the router, but not traffic originating at the router.

Source address and destination addresses are two of the most typical fields in an IP packet on which to base an access list. Specify source addresses to control packets from certain networking devices or hosts. Specify destination addresses to control packets being sent to certain networking devices or hosts.

You can also filter packets on the basis of transport layer information, such as whether the packet is a TCP, UDP, Internet Control Message Protocol (ICMP), or Internet Group Management Protocol (IGMP) packet.

ACL Workflow

The following image illustrates the workflow of an ACL.



IP Access List Process and Rules

Use the following process and rules when configuring an IP access list:

- The software tests the source or destination address or the protocol of each packet being filtered against the conditions in the access list, one condition (permit or deny statement) at a time.
- If a packet does not match an access list statement, the packet is then tested against the next statement in the list.
- If a packet and an access list statement match, the remaining statements in the list are skipped and the packet is permitted or denied as specified in the matched statement. The first entry that the packet matches determines whether the software permits or denies the packet. That is, after the first match, no subsequent entries are considered.
- If the access list denies the address or protocol, the software discards the packet and returns an ICMP Host Unreachable message. ICMP is configurable in the Cisco IOS XR software.

  ICMP type and code such as ECHO, ECHO-REPLY, MASK-REPLY, MASK-REQUEST, and so on are supported.
- If no conditions match, the software drops the packet because each access list ends with an unwritten or implicit deny statement. That is, if the packet has not been permitted or denied by the time it was tested against each statement, it is denied.
- The access list should contain at least one permit statement or else all packets are denied.

- Because the software stops testing conditions after the first match, the order of the conditions is critical. The same permit or deny statements specified in a different order could result in a packet being passed under one circumstance and denied in another circumstance.
- Only one access list per interface, per protocol, per direction is allowed.
- Inbound access lists process packets arriving at the router. Incoming packets are processed before being routed to an outbound interface. An inbound access list is efficient because it saves the overhead of routing lookups if the packet is to be discarded because it is denied by the filtering tests. If the packet is permitted by the tests, it is then processed for routing. For inbound lists, permit means continue to process the packet after receiving it on an inbound interface; **deny** means discard the packet.
- Outbound access lists process packets before they leave the router. Incoming packets are routed to the outbound interface and then processed through the outbound access list. For outbound lists, permit means send it to the output buffer; deny means discard the packet.
- An access list can not be removed if that access list is being applied by an access group in use. To remove an access list, remove the access group that is referencing the access list and then remove the access list.
- Before removing an interface, which is configured with an ACL that denies certain traffic, you must remove the ACL and commit your configuration. If this is not done, then some packets are leaked through the interface as soon as the **no interface <interface-name>** command is configured and committed.
- An access list must exist before you can use the **ipv4 | ipv6 access-group** command.

Helpful Hints for Creating IP Access Lists

Consider the following when creating an IP access list:

- Create the access list before applying it to an interface.
- Organize your access list so that more specific references in a network or subnet appear before more general ones.
- To make the purpose of individual statements more easily understood at a glance, you can write a helpful remark before or after any statement.

Source and Destination Addresses

Source address and destination addresses are two of the most typical fields in an IP packet on which to base an access list. Specify source addresses to control packets from certain networking devices or hosts. Specify destination addresses to control packets being sent to certain networking devices or hosts.

ACL Filtering by Wildcard Mask and Implicit Wildcard Mask

Address filtering uses wildcard masking to indicate whether the software checks or ignores corresponding IP address bits when comparing the address bits in an access-list entry to a packet being submitted to the access list. By carefully setting wildcard masks, an administrator can select a single or several IP addresses for permit or deny tests.

Wildcard masking for IP address bits uses the number 1 and the number 0 to specify how the software treats the corresponding IP address bits. A wildcard mask is sometimes referred to as an *inverted mask*, because a 1 and 0 mean the opposite of what they mean in a subnet (network) mask.

- A wildcard mask bit 0 means *check* the corresponding bit value.

- A wildcard mask bit 1 means *ignore* that corresponding bit value.

You do not have to supply a wildcard mask with a source or destination address in an access list statement. If you use the **host** keyword, the software assumes a wildcard mask of 0.0.0.0.

Unlike subnet masks, which require contiguous bits indicating network and subnet to be ones, wildcard masks allow noncontiguous bits in the mask.

You can also use Classless Inter-Domain Routing (CIDR) format (/x) in place of wildcard bits. For example, the IPv4 address 1.2.3.4 0.255.255.255 corresponds to 1.2.3.4/8 and for IPv6 address 2001:db8:abcd:0012:0000:0000:0000:0000 corresponds to 2001:db8:abcd:0012::0/64.

Transport Layer Information

You can filter packets on the basis of transport layer information, such as whether the packet is a TCP, UDP, ICMP, or IGMP packet.

Restrictions for Configuring Access Lists

You must be aware of the following restrictions for configuring access lists.

- IPv4 and IPv6 ACLs are not supported for loopback and interflex interfaces.
- If the Ternary content-addressable memory (TCAM) utilization is high and large ACLs are modified, then an error may occur. During such instances, remove the ACL from the interface and reconfigure the ACL. Later, reapply the ACL to the interface.
- Filtering of Multiprotocol Label Switching (MPLS) packets through interface ACL is not supported.
- Modifying an ACL when it is attached to the interface is supported.
- You can configure an ACL name with a maximum of 64 characters.
- You can configure an ACL name to comprise of only letters and numbers.

Including Comments in Access Lists

You can include comments (remarks) about entries in any named IP access list using the remark access list configuration command. The remarks make the access list easier for the network administrator to understand and scan. Each remark line is limited to 255 characters.

The remark can go before or after a **permit** or **deny** statement. You should be consistent about where you put the remark so it is clear which remark describes which **permit** or **deny** statement. For example, it would be confusing to have some remarks before the associated **permit** or **deny** statements and some remarks after the associated statements. Remarks can be sequenced.

Remember to apply the access list to an interface or terminal line after the access list is created.

IP Access List Entry Sequence Numbering

The ability to apply sequence numbers to IP access-list entries simplifies access list changes. Prior to this feature, there was no way to specify the position of an entry within an access list. If a user wanted to insert an entry (statement) in the middle of an existing list, all the entries after the desired position had to be removed,

then the new entry was added, and then all the removed entries had to be reentered. This method was cumbersome and error prone.

The IP Access List Entry Sequence Numbering feature allows users to add sequence numbers to access-list entries and resequence them. When you add a new entry, you choose the sequence number so that it is in a desired position in the access list. If necessary, entries currently in the access list can be resequenced to create room to insert the new entry.

Sequence Numbering Behavior

The following details the sequence numbering behavior:

- If entries with no sequence numbers are applied, the first entry is assigned a sequence number of 10, and successive entries are incremented by 10. The maximum configurable sequence number is 2147483643 for IPv4 and IPv6 entries. For other entries, the maximum configurable sequence number is 2147483646. If the generated sequence number exceeds this maximum number, the following message displays:

```
Exceeded maximum sequence number.
```

- If you provide an entry without a sequence number, it is assigned a sequence number that is 10 greater than the last sequence number in that access list and is placed at the end of the list.
- ACL entries can be added without affecting traffic flow and hardware performance.
- If a new access list is entered from global configuration mode, then sequence numbers for that access list are generated automatically.
- Distributed support is provided so that the sequence numbers of entries in the route processor (RP) and line card (LC) are synchronized at all times.
- This feature works with named standard and extended IP access lists. Because the name of an access list can be designated as a number, numbers are acceptable.

Adding Entries with Sequence Numbers: Example

In the following example, an new entry is added to IPv4 access list acl_5.

```
ipv4 access-list acl_5
 2 permit ipv4 host 192.0.2.1 any
 5 permit ipv4 host 198.51.100.44 any
 10 permit ipv4 host 198.51.100.1 any
 20 permit ipv4 host 198.51.100.2 any
configure
ipv4 access-list acl_5
 15 permit 203.0.113.1 255.255.255.0
end
ipv4 access-list acl_5
 2 permit ipv4 host 192.0.2.1 any
 5 permit ipv4 host 198.51.100.44 any
 10 permit ipv4 host 198.51.100.1 any
 15 permit ipv4 203.0.113.1 255.255.255.0 any
 20 permit ipv4 host 198.51.100.2 any
```

Adding Entries Without Sequence Numbers: Example

The following example shows how an entry with no specified sequence number is added to the end of an access list. When an entry is added without a sequence number, it is automatically given a sequence number that puts it at the end of the access list. Because the default increment is 10, the entry will have a sequence number 10 higher than the last entry in the existing access list.

```
configure
ipv4 access-list acl_10
permit 192.0.2.1 255.255.255.0
permit 198.51.100.1 255.255.255.0
permit 203.0.113.1 255.255.255.0
end

ipv4 access-list acl_10
 10 permit ip  192.0.2.1 255.255.255.0 any
 20 permit ip  198.51.100.1 255.255.255.0 any
 30 permit ip  203.0.113.1 255.255.255.0 any

configure
ipv4 access-list acl_10
permit  203.0.113.5 255.255.255.0
end

ipv4 access-list acl_10
 10 permit ip  192.0.2.1 255.255.255.0 any
 20 permit ip  198.51.100.1 255.255.255.0 any
 30 permit ip  203.0.113.1 255.255.255.0 any
 40 permit ip  203.0.113.5 255.255.255.0 any
```

Applying Access Lists

After you create an access list, you must reference the access list to make it work. Access lists can be applied on *either* outbound or inbound interfaces. This section describes guidelines on how to accomplish this task for both terminal lines and network interfaces.

Set identical restrictions on all the virtual terminal lines, because a user can attempt to connect to any of them.

For inbound access lists, after receiving a packet, Cisco IOS XR software checks the source address of the packet against the access list. If the access list permits the address, the software continues to process the packet. If the access list rejects the address, the software discards the packet and returns an ICMP host unreachable message. The ICMP message is configurable.

For outbound access lists, after receiving and routing a packet to a controlled interface, the software checks the source address of the packet against the access list. If the access list permits the address, the software sends the packet. If the access list rejects the address, the software discards the packet and returns an ICMP host unreachable message.

When you apply an access list that has not yet been defined to an interface, the software acts as if the access list has not been applied to the interface and accepts all packets. Note this behavior if you use undefined access lists as a means of security in your network.

Configuring IPv4 ACLs

This section describes the basic configuration of IPv4 ingress and egress ACLs.

Notes and Restrictions for Configuring IPv4 Ingress ACLs

IPv4 ingress ACLs are characterized by the following behavior for Cisco 8000 Series Routers. These restrictions are subject to change with respect to other platforms.

- Ingress IPv4 ACLs are supported on all interfaces except management interfaces.
- In Fixed system, maxmium number of ACLs allowed per NPU is 45, In distributed system, maxmium number of ACLs allowed per NPU is 30.
- Packet Length is not supported.
- ACL logging with input interface (using the **log-input** keyword) is not supported.

Notes and Restrictions for Configuring IPv4 Egress ACLs

IPv4 egress ACLs are characterized by the following behavior.

- ACL is not supported on Management interface on egress direction.
- ACL logging is not supported on egress direction.

Configuring an Ingress IPv4 ACL on a HundredGigE Interface

Use the following configuration to configure an ingress IPv4 ACL on a HundredGigE interface.

```
/* Configure a HundredGigE interface with an IPv4 address */
Router(config)# interface HundredGigE 0/0/0/0
Router(config-if)# ipv4 address 192.0.2.1 255.255.255.0
Router(config-if)# no shut
Router(config-if)# commit
Thu Jul 11 08:46:51.930 UTC
Router(config-if)# exit

/* Verify if the interface is up */
Router(config)# do show ipv4 interface brief

Thu Jul 11 08:46:51.930 UTC
Interface                  IP-Address      Status          Protocol Vrf-Name
HundredGigE 0/0/0/0         192.0.2.1        Up              Up       default

/* Configure an IPv4 ingress ACL */
Router(config)# ipv4 access-list V4-ACL-INGRESS
Router(config-ipv4-acl)# 10 permit tcp 192.0.2.2 255.255.255.0 any
Router(config-ipv4-acl)# 20 deny udp any any
Router(config-ipv4-acl)# 30 permit ipv4 192.0.2.64 255.255.255.0 any
Router(config-ipv4-acl)# commit
Thu Jul 11 08:55:12.806 UTC

/* Verify the ingress ACL creation */
Router(config)# do show access-lists ipv4
Thu Jul 11 08:55:44.824 UTC
...
ipv4 access-list V4-ACL-INGRESS
```

```
 10 permit tcp 192.0.2.2 255.255.255.0 any
 20 deny udp any any
 30 permit ipv4 192.0.2.64 255.255.255.0 any


/* Apply the ingress ACL to the HundredGigE interface */
Router(config)# interface HundredGigE 0/0/0/0
Router(config-if)# ipv4 access-group V4-ACL-INGRESS ingress
Router(config-if)# commit
Thu Jul 11 09:01:26.744 UTC
Router(config-if)# exit

/* Verify if the ingress ACL has been successfully applied to the interface */
Router(config)# do show ipv4 interface
Thu Jul 11 09:01:50.445 UTC
HundredGigE 0/0/0/0 is Up, ipv4 protocol is Up
  Vrf is default (vrfid 0x60000000)
  Internet address is 192.0.2.1/24
  MTU is 1514 (1500 is available to IP)
  Helper address is not set
  Directed broadcast forwarding is disabled
  Outgoing access list is not set
  Inbound  common access list is not set, access list is V4-ACL-INGRESS
  Proxy ARP is disabled
  ICMP redirects are never sent
  ICMP unreachables are always sent
  ICMP mask replies are never sent
  Table Id is 0xe0000000
```

You have successfully configured an IPv4 ingress ACL on a HundredGigE interface.

Configuring an Egress IPv4 ACL on a HundredGigE Interface

Use the following configuration to configure an egress IPv4 ACL on a HundredGigE interface.

```
/* Configure a HundredGigE interface with an IPv4 address */
Router(config)# interface HundredGigE 0/0/0/0
Router(config-if)# ipv4 address 198.51.100.1 255.255.255.0
Router(config-if)# no shut
Router(config-if)# commit
Thu Jul 11 08:55:12.806 UTC
Router(config-if)# exit

/* Verify if the interface is up */
Router(config)# do show ipv4 interface brief
Thu Jul 11 08:55:44.824 UTC

Interface                      IP-Address      Status          Protocol Vrf-Name
HundredGigE 0/0/0/0         192.0.2.1          Up              Up       default
HundredGigE 0/0/0/1         198.51.100.1       Up              Up       default

/* Configure an IPv4 egress ACL */
Router(config)# ipv4 access-list V4-ACL-EGRESS
Router(config-ipv4-acl)# 10 permit ipv4 203.0.113.1 255.255.255.0 192.0.2.1 0.255.255.255
Router(config-ipv4-acl)# 20 deny ipv4 any any
Router(config-ipv4-acl)# commit
Thu Jul 11 08:59:10.093 UTC

/* Verify the egress ACL creation */
Router(config)# do show access-lists ipv4
Thu Jan 25 10:25:19.896 IST
ipv4 access-list V4-ACL-EGRESS
```

```
 10 permit ipv4 203.0.113.1 255.255.255.0 192.0.2.1 255.255.255.0
 20 deny ipv4 any any
...

/* Apply the egress ACL to the HundredGigE interface */
Router(config)# interface HundredGigE 0/0/0/1
Router(config-if)# ipv4 access-group V4-ACL-EGRESS egress
Router(config-if)# commit
Thu Jul 11 09:19:49.569 UTC
Router(config-if)# exit

/* Verify if the egress ACL has been successfully applied to the interface */
Router(config)# do show ipv4 interface
Thu Jul 11 09:01:50.445 UTC
HundredGigE 0/0/0/1 is Up, ipv4 protocol is Up
  Vrf is default (vrfid 0x60000000)
  Internet address is 198.51.100/24
  MTU is 1514 (1500 is available to IP)
  Helper address is not set
  Directed broadcast forwarding is disabled
  Outgoing access list is V4-ACL-EGRESS
  Inbound  common access list is not set, access list is not set
  Proxy ARP is disabled
  ICMP redirects are never sent
  ICMP unreachables are always sent
  ICMP mask replies are never sent
  Table Id is 0xe0000000
...
```

You have successfully configured an IPv4 egress ACL on a HundredGigE interface. For more information on logging messages, see Understanding IP Access List Logging Messages, on page 27.

Configuring IPv6 ACLs

You can filter IP version 6 (IPv6) traffic by creating IPv6 access control lists (ACLs) and applying them to interfaces similar to the way that you create and apply IP version 4(IPv4) named ACLs.

Restrictions and Guidelines

The following restrictions and guidelines apply while configuring IPv6 ACLs:

- Ingress IPv6 ACLs are supported on all interfaces.
- From Release 7.3.1 onwards, the maximum number of ACLs allowed per router is 126.

  In earlier releases, for the Cisco 8100 and 8200 Series fixed chassis, the maximum number of ACLs allowed per router is 45. For the Cisco 8800 modular chassis, the maximum number of ACLs allowed per router is 30.
- ACL logging with input interface (using the **log-input** keyword) is not supported.
- Packet Length (using the **pkt-length** keyword) is not supported.
- TCP flags are not supported on ingress and egress IPv6 ACLs.

Configuring an Ingress IPv6 ACL on a HundredGigE Interface

Use the following configuration to configure an ingress IPv6 ACL on a HundredGigE interface.

```
/* Configure a HundredGigE interface with an IPv6 address */
Router(config)# interface HundredGigE 0/0/0/0
Router(config-if)# ipv6 address 2001::1/64
Router(config-if)# no shut
Router(config-if)# commit
Thu Jul 11 09:28:07.759 UTC
Router(config-if)# exit

/* Verify if the interface is up */
Router(config)# do show ipv6 interface brief
Thu Jul 11 09:28:43.657 UTC
HundredGigE 0/0/0/0 [Up/Up]
    fe80::bd:b9ff:fea9:5606
    2001::1
…

/* Configure an IPv6 ingress ACL */
Router(config)# ipv6 access-list V6-INGRESS-ACL
Router(config-ipv6-acl)# 10 permit ipv6 any any
Router(config-ipv6-acl)# 20 deny udp any any
Router(config-ipv6-acl)# commit
Thu Jul 11 09:41:02.625 UTC
Router(config-ipv6-acl)# exit


/* Verify the ingress ACL creation */
Router(config)# do show access-lists ipv6
Thu Jul 11 09:41:37.260 UTC
ipv6 access-list V6-INGRESS-ACL
 10 permit ipv6 any any
 20 deny udp any any


/* Apply the ingress ACL to the HundredGigE interface */
Router(config)# interface HundredGigE 0/0/0/0
Router(config-if)# ipv6 access-group V6-INGRESS-ACL ingress
Router(config-if)# commit
Thu Jul 11 09:43:59.733 UTC
Router(config-if)# exit

/* Verify if the ingress ACL has been successfully applied to the interface */
Router(config)# do show ipv6 interface
Thu Jan 25 11:34:08.028 IST
HundredGigE 0/0/0/0 is Up, ipv6 protocol is Up, Vrfid is default (0x60000000)
  IPv6 is enabled, link-local address is fe80::bd:b9ff:fea9:5606
  Global unicast address(es):
    2001::1, subnet is 1001::/64
  Joined group address(es): ff02::1:ff00:1 ff02::1:ffa9:5606 ff02::2
      ff02::1
  MTU is 1514 (1500 is available to IPv6)
  ICMP redirects are disabled
  ICMP unreachables are enabled
  ND DAD is enabled, number of DAD attempts 1
  ND reachable time is 0 milliseconds
  ND cache entry limit is 1000000000
  ND advertised retransmit interval is 0 milliseconds
  Hosts use stateless autoconfig for addresses.
  Outgoing access list is not set
  Inbound  common access list is not set, access list is V6-INGRESS-ACL
  Table Id is 0xe0800000
```

```
  Complete protocol adjacency: 0
  Complete glean adjacency: 0
  Incomplete protocol adjacency: 0
  Incomplete glean adjacency: 0
  Dropped protocol request: 0
  Dropped glean request: 0
…
```

You have successfully configured an IPv6 ingress ACL on a HundredGigE interface.

Configuring an Egress IPv6 ACL on a HundredGigE Interface

Use the following configuration steps to configure an egress IPv6 ACL on a HundredGigE interface.

```
/* Configure a HundredGigE interface with an IPv6 address */
Router(config)# interface HundredGigE 0/0/0/1
Router(config-if)# ipv6 address 2001::1/64
Router(config-if)# no shut
Router(config-if)# commit
Thu Jan 25 11:41:25.778 IST
Router(config-if)# exit

/* Verify if the interface is up */
Router(config)# do show ipv6 interface brief
Thu Jul 11 09:47:50.812 UTC
HundredGigE 0/0/0/0 [Up/Up]
    fe80::bd:b9ff:fea9:5606
    1001::1
HundredGigE 0/0/0/1 [Up/Up]
    fe80::23:e9ff:fea8:a44e
    2001::1

/* Configure an IPv6 egress ACL */
Router(config)# ipv6 access-list V6-EGRESS-ACL
Router(config-ipv6-acl)# 10 permit ipv6 any any
Router(config-ipv6-acl)# 20 deny udp any any
Router(config-ipv6-acl)# commit
Thu Jul 11 09:50:40.566 UTC
Router(config-ipv6-acl)# exit

/* Verify the egress ACL creation */
Router(config)# do show access-lists ipv6
Thu Jul 11 09:51:16.687 UTC
ipv6 access-list V6-EGRESS-ACL
 10 permit ipv6 any any
 20 deny udp any any
…

/* Apply the egress ACL to the HundredGigE interface */
Router(config)# interface HundredGigE 0/0/0/1
Router(config-if)# ipv6 access-group V6-EGRESS-ACL egress
Router(config-if)# commit
Thu Jul 11 09:52:57.751 UTC
Router(config-if)# exit

/* Verify if the egress ACL has been successfully applied to the interface */
Router(config)# do show ipv6 interface
Thu Jul 11 09:53:41.365 UTC
…
HundredGigE is Up, ipv6 protocol is Up, Vrfid is default (0x60000000)
  IPv6 is enabled, link-local address is fe80::23:e9ff:fea8:a44e
  Global unicast address(es):
```

```
    2001::1, subnet is 2001::/64
  Joined group address(es): ff02::1:ff00:1 ff02::1:ffa8:a44e ff02::2
      ff02::1
  MTU is 1514 (1500 is available to IPv6)
  ICMP redirects are disabled
  ICMP unreachables are enabled
  ND DAD is enabled, number of DAD attempts 1
  ND reachable time is 0 milliseconds
  ND cache entry limit is 1000000000
  ND advertised retransmit interval is 0 milliseconds
   Hosts use stateless autoconfig for addresses.
  Outgoing access list is V6-EGRESS-ACL
  Inbound  common access list is not set, access list is not set
  Table Id is 0xe0800000
  Complete protocol adjacency: 0
  Complete glean adjacency: 0
  Incomplete protocol adjacency: 0
  Incomplete glean adjacency: 0
  Dropped protocol request: 0
  Dropped glean request: 0
...
```

You have successfully configured an IPv6 egress ACL on a HundredGigE interface.

Configuring Ingress and Egress IPv6 ACLs on Bundle Interfaces

Use the following configuration to configure ingress and egress IPv6 ACLs on a bundle interface.

```
/* Configure a bundle interface with an IPv6 address */
Router(config)# interface Bundle-Ether 1
Router(config-if)# ipv6 address 2001::1/64
Router(config-if)# no shut
Router(config-if)# commit
Thu Jul 11 09:56:40.603 UTC
Router(config-if)# exit

/* Configure an IPv6 egress ACL */
Router(config)# ipv6 access-list V6-EGRESS-ACL-bundle interface
Router(config-ipv6-acl)# 10 permit tcp any any range 3000 4000
Router(config-ipv6-acl)# 20 permit ipv6 any any
Router(config-ipv6-acl)# commit
Thu Jul 11 10:02:34.568 UTC
Router(config-ipv6-acl)# exit

/* Configure an IPv6 ingress ACL to deny ingress traffic on the bundle interface */
Router(config)# ipv6 access-list V6-DENY-INGRESS-ACL
Router(config-ipv6-acl)# 10 deny ipv6 any any
Router(config-ipv6-acl)# commit
Thu Jul 11 10:03:43.411 UTC
Router(config-ipv6-acl)# exit

/* Verify the egress and ingress ACL creation */
Router(config)# do show access-lists ipv6
Thu Jul 11 10:04:35.798 UTC
ipv6 access-list V6-DENY-INGRESS-ACL
 10 deny ipv6 any any
ipv6 access-list V6-EGRESS-ACL-BI
 10 permit tcp any any range 3000 4000
 20 permit ipv6 any any
...

/* Apply the egress and ingress ACLs to the bundle interface */
```

```
Router(config)# interface Bundle-Ether 1
Router(config-if)# ipv6 access-group V6-EGRESS-ACL-BI egress
Router(config-if)# ipv6 access-group V6-DENY-INGRESS-ACL ingress
Router(config-if)# commit
Thu Jul 11 10:06:06.452 UTC
Router(config-if)# exit

/* Verify if the ACLs have been successfully applied to the interface */
Router(config)# do show ipv6 interface
Thu Jul 11 10:06:49.975 UTC
…
Bundle-Ether1 is Down, ipv6 protocol is Down, Vrfid is default (0x60000000)
  IPv6 is enabled, link-local address is fe80::1:10ff:fe87:8d04 [TENTATIVE]
  Global unicast address(es):
    2001::1, subnet is 2001::/64 [TENTATIVE]
  Joined group address(es): ff02::2 ff02::1
  MTU is 1514 (1500 is available to IPv6)
  ICMP redirects are disabled
  ICMP unreachables are enabled
  ND DAD is enabled, number of DAD attempts 1
  ND reachable time is 0 milliseconds
  ND cache entry limit is 1000000000
  ND advertised retransmit interval is 0 milliseconds
  ND router advertisements are sent every 160 to 240 seconds
  ND router advertisements live for 1800 seconds
  Hosts use stateless autoconfig for addresses.
  Outgoing access list is V6-EGRESS-ACL-BI
  Inbound  common access list is not set, access list is V6-DENY-INGRESS-ACL
  Table Id is 0xe0800000
  Complete protocol adjacency: 0
  Complete glean adjacency: 0
  Incomplete protocol adjacency: 0
  Incomplete glean adjacency: 0
  Dropped protocol request: 0
  Dropped glean request: 0
```

You have successfully configured ingress and egress IPv6 ACLs on a bundle interface.

Configuring Extended Access Lists

Use Extended Access Lists to verify more than just the source address of the packets. Attributes such as destination address, specific IP protocols, UDP or TCP port numbers, DSCP, and so on are validated. Traffic is controlled by a comparison of the attributes stated in the ACL with those in the incoming or outgoing packets.

Configuration Example

To configure Extended Access Lists, you must completed create an access list and specify the condition to allow or deny the network traffic.

```
/* Enter the global configuration mode and create the access list*/
Router# configure
Router(config)# ipv4 access-list acl_1
Router(config-ipv4-acl)# 10 remark Do not allow user1 to telnet out
/*Specify the condition to allow or deny the network traffic.*/
Router(config-ipv4-acl)# 10 permit 172.16.0.0 0.0.255.255
Router(config-ipv4-acl)# 20 deny 192.168.34.0 0.0.0.255
Router(config-ipv4-acl)commit
```

Running Configuration

```
Router#show running-config
Mon Jul 29 05:56:14.315 UTC
Building configuration...
!! IOS XR Configuration

!
ipv4 access-list acl_1
 10 permit ipv4 172.16.0.0 0.0.255.255 any
 20 deny ipv4 192.168.34.0 0.0.0.255 any
!
```

Verification

```
Router#show access-lists ipv4 acl_1 hardware ingress location 0/0/CPU0
Tue Jul 2 08:03:29.495 UTC
ipv4 access-list acl_1
66 deny igmp 30.0.20.0 0.0.0.255 30.0.10.0 0.0.0.255 v3-report (11604 matches)
67 deny igmp host 30.0.20.1 host 30.0.10.1 v2-report
```

IPv4 and IPv6 ACL in Class Map

Quality of Service (Qos) features are enhanced to support these:

- Support on L3 interface, sub-interface, bundle interface and bundle sub-interface
- Support for only ingress direction
- IPv6-supported match fields:
    - Destination Port
    - Fragment bit
    - ICMP type and code
    - IGMP type and code
    - IPv6 Destination Address
    - IPv6 Source Address
    - IPv6 Protocol
    - Precedence/DSCP
    - Source Port

Configuring IPv6 ACL QoS - An Example

This example shows how to configure IPv6 ACL QoS with IPv4 ACL and other fields :

```
ipv6 access-list aclv6
10 permit ipv6 1111:6666::2/64 1111:7777::2/64 authen
30 permit tcp host 1111:4444::2 eq 100 host 1111:5555::2
```

```
!

ipv4 access-list aclv4
10 permit ipv4 host 10.6.10.2 host 10.7.10.2
!

class-map match-any c.aclv6
match access-group ipv6 aclv6
match access-group ipv4 aclv4
match cos 1
end-class-map
!

policy-map p.aclv6
class c.aclv6
  set precedence 3
!
class class-default
!
end-policy-map
!
```

User-Defined TCAM Keys for IPv4 and IPv6

Access-lists use a TCAM (internal and external) to perform the lookup and action resolution on each packet. The TCAM is a valuable and constrained resource in hardware, which must be shared by multiple features. Therefore, the space (key width) available for these key definitions is also constrained. A key definition specifies which qualifier and action fields are available to the ACL feature when performing the lookup.

The key definitions are specific to a given ACL type, which can depend on the following attributes of the access-list:

- Direction of attachment only for ingress
- Protocol type (IPv4/IPv6)

Because the default key definitions are constrained (do not include all qualifier/action fields), User-Defined Key (UDK) definitions are supported for the following types:

- Traditional Ingress IPv4 ACL (uncompressed)
- Traditional Ingress IPv6 ACL (uncompressed)

The User-Defined TCAM Key (UDK) functionality provides the flexibility to define your own TCAM key for ingress, traditional, or IPv4 and IPv6 ACL only:

To include the well-known fields in the default TCAM key, see IPv4 and IPv6 Key Formats, on page 18.

A User-Defined TCAM Key (UDK) can be defined globally or locally per line card. If both global and local UDK is available for a line card, then global UDK is be ignored for the line card.

A UDK can be configured using the following command:

```
hw-module profile tcam format access-list [ipv4 | ipv6] field1 field2[location rack/slot/cpu0]
```

To define UDK globally, you can ignore the location option.

```
hw-module profile tcam format access-list [ipv4 | ipv6] field1field2
```

Note It is recommeded to use global UDK for Cisco 8000 Series Routers Fixed platform.

User-Defined Fields

TCAM key consists of several qualifiers. Use the sets of qualifiers to filter packets for a given ACL. The User-Defined Field (UDF) allows you to define a custom qualifier by specifying the location and size of the field, using the following UDF command:

udf *udf-name* **header** *[inner | outer] [l3 | l4]* **offset** *byte-offset* **length** *no of bytes*

You can add the UDF to a UDK as follows.

```
hw-module profile tcam format access-list [ipv4 | ipv6] qualifiers [udf1 udf-name udf2
udf-name] [location rack/slot/cpu0]
```

Note You can define up to 8 UDFs systemwide. Currently, you can define UDFs globally.

Restrictions

- Cisco 8000 Series Routers support UDF only on L3 interfaces and not on L2 ports.
- Deep Packet Inspection is available only up to 128 Bytes inside the packet initiating from the L2 header.
- Cisco 8000 Series Routers support UDF only in ingress direction.
- Cisco 8000 Series Routers support only L3 and L4 base offsets for both inner and outer headers.
- Cisco 8000 Series Routers support only four bytes of match length.
- Modification for UDF configuration is allowed, but you must reload the related line card to be effective using the **reload location** *node Id* command.
- Modification for UDK is not supported using the **hw-module profile tcam format** command.

  First, remove the existing UDK using the **no hw-module profile tcam format** command, then add a new UDK definition.
- If you configure UDK, you cannot use the default keys. But you can explicitly define the default fields in UDK.

Configuration Example

Steps

1. Create an UDF and define UDK.
2. Manually, reload the node on the line card.
3. Configure ACL using fields defined in UDK.
4. Attach ACL to an interface in ingress direction.

Configuration

The following example shows how to deny packets with the following condition:

- The packets with the source address as 192.0.2.0 and destination address as 203.0.113.0
- The packets with the payload pattern of 0x4567 at an offset of 48 bytes from the L3 header

```
/* Create an UDF and define global UDK and UDF*\
Router#configure terminal
Router(config)#udf udf_outerl3_2b header outer l3 offset 48 length 2
Router(config)#hw-module profile tcam format access-list ipv4 ipv4-sip ipv4-dip udf1
udf_outerl3_2b

In order to activate/deactivate this ipv4 profile, you must manually reload line cards
Router(config)#exit

 /* Reload the node on the Cisco 8000 Series Routers line card*\
Router#reload location 0/8/CPU0
Wed Aug 21 14:12:40.123 UTC
Proceed with reload? [confirm]

Router#:Aug 21 14:12:44.120 UTC: fsdbagg[216]: %PKT_INFRA-FM-4-FAULT_MINOR : ALARM_MINOR
:FABRIC-PLANE-5 :DECLARE :: Fabric Plane-5 DOWN
Router:Aug 21 14:12:44.123 UTC: fsdbagg[216]: %PKT_INFRA-FM-4-FAULT_MINOR : ALARM_MINOR
:FABRIC-PLANE-6 :DECLARE :: Fabric Plane-6 DOWN

/*Configure ACL for User Defined Key*\
Router(config)#ipv4 access-list acl1
Router(config-ipv4-acl)10 deny ipv4 192.0.2.0 203.0.113.0 any udf udf_outerl3_2b 0x4567
0xffff
Router(config-ipv4-acl)#exit
Router(config)#interface HundredGigE 0/0/0/24
Router (config-if)#ipv4 access-group acl1 ingress
```

The following example shows how to deny the `IP in IP Tunneling` packet with the following condition:

- Packet with the inner IP header having the DSCP as AF42.
- Packet with the payload pattern of 0x12345678 at offset of 20 bytes from outer layer 4 header.

```
Router#configure terminal
Router(config)#udf udf_innerl3_1b header inner l3 offset  1  length 1
Router(config)#udf udf_outerl4_4b header outer l4 offset  20  length 4
Router(config)#hw-module profile tcam format access-list ipv4 protocol udf1 udf_innerl3_1b
  udf udf_outerl4_4b
```

IPv4 and IPv6 Key Formats

The following table shows the qualifier fields that are supported in the IPv4 and IPv6 key formats.

Table 1: Qualifier Fields Supported in IPv4 and IPv6 Key Formats

Parameter	Default TCAM Key	
	IPv4	IPv6
Destination Address	Supported	Supported

Parameter	Default TCAM Key	
	IPv4	IPv6
Destination Port	Supported	Supported
Fragment bit	Supported	Supported
ICMP type and code	Supported	Supported
IGMP type and code	Supported	Supported
Protocol/Next Header	Supported	Supported
Precedence/DSCP	Supported	Supported
Source Address	Supported	Supported
Source Port	Supported	Supported
TCP Flags	Supported	Not supported
Time to live (TTL) Match	Supported	Not supported
UDF 1-8	Not supported	Not supported

The following table shows the action fields supported in the IPv4 and IPv6 key formats.

Table 2: Action Fields Supported in IPv4 and IPv6 Key Formats

Parameter	Default Action Field	
	IPv4	IPv6
Permit	Supported	Supported
Deny	Supported	Supported
Next Hop	Supported	Supported
Log	Supported for Ingress only	Supported for Ingress only
Capture	Supports only ingress Encapsulated Remote SPAN (ERSPAN)	Supports only ingress Encapsulated Remote Switch port Analyzer (ERSPAN)
Stats Counter	Deny stats is always enabled (Permit stats is not supported)	Deny stats is always enabled (Permit stats is not supported)

Modifying ACLs

This section describes a sample configuration for modification of ACLs.

```
*/ Create an Access List*/
Router(config)#ipv4 access-list acl_1

*/Add entries (ACEs) to the ACL*/
Router(config-ipv4-acl)#10 permit ip host 10.3.3.3 host 172.16.5.34
Router(config-ipv4-acl)#20 permit icmp any any
Router(config-ipv4-acl)#30 permit tcp any host 10.3.3.3
Router(config-ipv4-acl)#end

*/Verify the entries of the ACL*/:
Router#show access-lists ipv4 acl_1
ipv4 access-list acl_1
10 permit ip host 10.3.3.3 host 172.16.5.34
20 permit icmp any any
30 permit tcp any host 10.3.3.3

*/Add new entries, one with a sequence number "15" and another without a sequence number
to the ACL. Delete an entry with the sequence number "30":*/
Router(config)#ipv4 access-list acl_1
Router(config-ipv4-acl)# 15 permit 10.5.5.5 0.0.0.255
Router(config-ipv4-acl)# no 30
Router(config-ipv4-acl)# permit 10.4.4.4 0.0.0.255
Router(config-ipv4-acl)# commit


*/When an entry is added without a sequence number, it is automatically given a sequence
number
that puts it at the end of the access list. Because the default increment is 10, the entry
 will have a sequence
number 10 higher than the last entry in the existing access list*/

*/Verify the entries of the ACL:*/
Router#show access-lists ipv4 acl_1
ipv4 access-list acl_1
 10 permit ipv4 host 10.3.3.3 host 172.16.5.34

15 permit 10.5.5.5 0.0.0.255---*/newly added ACE (with the sequence number)*/
20 permit icmp any any
30 permit ipv4 10.4.4.0 0.0.0.255 any ---*/newly added ACE (without the sequence number)*/

*/The entry with the sequence number 30, that is, "30 permit tcp any host 10.3.3.3" is
deleted from the ACL*/
```

You have successfully modified ACLs in operation.

Configuring ACL-based Forwarding

Converged networks carry voice, video, and data. Users may need to route certain traffic through specific paths instead of using the paths computed by routing protocols. This is achieved by specifying the next-hop address in ACL configurations, so that the configured next-hop address from ACL is used for forwarding packet towards its destination instead of routing through packet-based destination address lookup. This feature of using next-hop in ACL configurations for forwarding is called ACL Based Forwarding (ABF).

ACL-based forwarding enables you to choose service from multiple providers for broadcast TV over IP, IP telephony, data, and so on, which provides a cafeteria-like access to the Internet. Service providers can divert user traffic to various content providers.

Restrictions

- Traffic outages can occur during transitions from an existing nexthop to another nexthop.
- IPv4 and IPv6 ABF nexthops routed over GRE interfaces are not supported.
- VRF-select (where only the VRF is configured for the nexthop) is not supported in ABF for IPv4 and IPv6 addresses.
- Logging of permit statistics for ABF is not supported.

Feature Highlights

- ABF supports nexthop modifications. You can modify a nexthop, remove a nexthop, or make changes between existing nexthops.

Note While defining an ACE rule, you must specify the VRF for all nexthops unless the nexthop is in the default VRF. This process ensures that the packets take the right path towards the nexthop.

- As ABF is ACL-based, packets that do not match an existing rule (ACE) in the ACL are subjected to the default ACL rule (drop all). If the ACL is being used for ABF-redirect only (not for security), then include an explicit ACE rule at the end of the ACL (lowest user priority) to match and "permit" all traffic. This ensures that all traffic that does not match an ABF rule is permitted and forwarded as normal.
- ABF is supported on permit rules only.
- ABF default route is not supported.
- Packets punted in the ingress direction from the NPU to the linecard CPU are not subjected to ABF treatment due to lack of ABF support in the slow path. These packets will be forwarded normally based on destination-address lookup by the software dataplane. Some examples of these types of packets are (but are not limited to) packets with IPv4 options, IPv6 extension headers, and packets destined for glean (unresolved/incomplete) adjacencies.

Configuration Example

To configure ACL-based forwarding for IPv4 packets, use the following steps:

1. Enter IPv4 access list configuration mode and configure an ACL.
2. Set the conditions for the ACL.
3. Configure nexthop addresses for ABF.

Configuration

To configure ACL-based forwarding for IPv4 packets, use the following configuration example:

```
/* Enter IPv4 access list configuration mode and configure an ACL: */
Router# configure
Router(config)# ipv4 access-list abf-acl

/* Set the conditions for the ACL and configure ABF: */
/* The next hop for this entry is specified. */
Router(config-ipv4-acl)# 10 permit ipv4 192.168.18.0 0.255.255.255 any nexthop1 ipv4
192.168.20.2
Router(config-ipv4-acl)# 15 permit ipv4 192.168.21.0 0.0.0.255 any
Router(config-ipv4-acl)# 20 permit ipv4 192.168.22.0 0.0.255.255 any nexthop1 ipv4
192.168.23.2
/* More than two nexthops */
Router(config-ipv4-acl)# 25 permit tcp any range 2000 3000 any range 4000 5000 nexthop1
ipv4 192.168.23.1 nexthop2 ipv4 192.168.24.1 nexthop3 ipv4 192.168.25.1

/* VRF support on ABF */
Router(config-ipv4-acl)# 30 permit tcp any eq www host 192.168.12.2 precedence immediate
nexthop1 vrf vrf1_ipv4 ipv4 192.168.13.2 nexthop2 vrf vrf1_ipv4 ipv4 192.168.14.2

Router(config-ipv4-acl)# 35 permit ipv4 any any

Router(config-ipv4-acl)# commit
```

To configure ACL-based forwarding for IPv6 packets, use the following configuration example:

```
/* Enter IPv6 access list configuration mode and configure an ACL: */
Router# configure
Router(config)# ipv6 access-list abf-acl

/* Set the conditions for the ACL and configure ABF: */
/* The next hop for this entry is specified. */
Router(config-ipv6-acl)# 10 permit ipv6 2001:db8::/32 any nexthop1 ipv6 2001:db8::2

/* More than two nexthops */
Router(config-ipv6-acl)# 25 permit tcp any range 2000 3000 any range 4000 5000 nexthop1
ipv6 2001:db8::3 nexthop2 ipv6 2001:db8::4 nexthop3 ipv6 2001:db8::5

/* VRF support on ABF */
Router(config-ipv6-acl)# 30 permit tcp any eq www host 2001:db8::8 precedence immediate
nexthop1 vrf vrf1_ipv6 ipv6 2001:db8::7 nexthop2 vrf vrf1_ipv6 ipv6 2001:db8::6

Router(config-ipv6-acl)# 35 permit ipv6 any any

Router(config-ipv6-acl)# commit
```

Running Configuration

```
Router# show access-lists ipv4
ipv4 access-list abf-acl
10 permit ipv4 192.168.18.0 0.255.255.255 any nexthop1 192.168.20.2
15 permit ipv4 192.168.21.0 0.0.0.255 any
20 permit ipv4 192.168.22.0 0.0.255.255 any nexthop1 192.168.23.2
25 permit tcp any range 2000 3000 any range 4000 5000 nexthop1 ipv4 192.168.23.1 nexthop2
ipv4 192.168.24.1 nexthop3 ipv4 192.168.25.1
30 permit tcp any eq www host 192.168.12.2 precedence immediate nexthop1 vrf vrf1_ipv4 ipv4
 192.168.13.2 nexthop2 vrf vrf1_ipv4 ipv4 192.168.14.2
35 permit ipv4 any any
!
Router# show access-lists ipv6
ipv6 access-list abf-acl-ipv6
 10 permit ipv6 2001:db8::/32 any nexthop1 ipv6 2001:db8::2
 25 permit tcp any range 2000 3000 any range 4000 5000 nexthop1 ipv6 2001:db8::3 nexthop2
ipv6 2001:db8::4 nexthop3 ipv6 2001:db8::5
 30 permit tcp any eq www host 2001:db8::8 precedence immediate nexthop1 vrf vrf1_ipv6 ipv6
```

```
2001:db8::7 nexthop2 vrf vrf1_ipv6 ipv6 2001:db8::6
35 permit ipv6 any any
```

Verification

Use the following command to verify the IP nexthop state in ABF to ensure that the expected nexthop is up:

```
Router# show access-lists ipv4 abf nexthops client pfilter_ea location 0/3/CPU0
Tue May 17 22:25:05.940 UTC

 ACL name : abf-acl
  ACE seq.           NH-1                  NH-2                  NH-3
 ---------  ---------------------  ---------------------  ---------------------
        20    Global 192.168.23.2            Not present            Not present
    status                     UP            Not present            Not present
     exist                     No            Not present            Not present
    pd ctx                Present            Not present            Not present
              Track not present      Track not present                     --
        25    Global 192.168.23.1    Global 192.168.24.1    Global 192.168.25.1
    status                     UP                     UP                     UP
     exist                    Yes                    Yes                    Yes
    pd ctx                Present                Present                Present
              Track not present      Track not present      Track not present
```

Use the following command to verify if ABF is currently attached to any interfaces at any linecard:

```
Router# show access-lists usage pfilter location all
sh access-lists ipv4 abf nexthops client pfilter_ea loc 0/RP0/CPU0
Wed Jul 29 20:48:18.559 UTC

ACL name : abf-1
  ACE seq.         NH-1             NH-2             NH-3
 ---------  ---------------  ---------------  ---------------
        10    27.138.216.32         28.0.0.2      Not present
    status               UP               UP      Not present
at status       Not Present      Not Present      Not present
     exist                No              Yes      Not present
       vrf           default          default      Not present
     track       Not present      Not present      Not present
    pd ctx           Present          Present      Not present
```

Associated Commands

- ipv4 access-list
- ipv6 access-list
- show access-lists ipv4
- show access-lists ipv6

Associated Topics

- Configuring IPv4 ACLs
- Configuring IPv6 ACLs

Access Control List Counters

In Cisco IOS XR software, ACL counters are maintained both in hardware and software. Hardware counters are used for packet filtering applications. Software counters are used by all the applications mainly involving software packet processing.

Software counters are updated for the packets processed in software, for example, exception packets punted to the LC CPU for processing, or ACL used by routing protocols, and so on. The counters that are maintained are an aggregate of all the software applications using that ACL. To display software-only ACL counters, use the **show access-lists ipv4** *access-list-name* [**sequence** *number*] command in EXEC mode.

Configuring ACLs with Fragment Control

The non-fragmented packets and the initial fragments of a packet were processed by IP extended access lists (if you apply this access list), but non-initial fragments were permitted, by default. However, now, the IP Extended Access Lists with Fragment Control feature allows more granularity of control over non-initial fragments of a packet. Using this feature, you can specify whether the system examines non-initial IP fragments of packets when applying an IP extended access list.

As non-initial fragments contain only Layer 3 information, these access-list entries containing only Layer 3 information, can now be applied to non-initial fragments also. The fragment has all the information the system requires to filter, so the access-list entry is applied to the fragments of a packet.

This feature adds the optional **fragments** keyword to the following IP access list commands: **deny** and **permit** . By specifying the **fragments** keyword in an access-list entry, that particular access-list entry applies only to non-initial fragments of packets; the fragment is either permitted or denied accordingly.

The behavior of access-list entries regarding the presence or absence of the **fragments** keyword can be summarized as follows:

If the Access-List Entry has...	Then...

...no **fragments** keyword and all of the access-list entry information matches	For an access-list entry containing only Layer 3 information:
	• The entry is applied to non-fragmented packets, initial fragments, and non-initial fragments.
	For an access-list entry containing Layer 3 and Layer 4 information:
	• The entry is applied to non-fragmented packets and initial fragments.
	  • If the entry matches and is a **permit** statement, the packet or fragment is permitted.
	  • If the entry matches and is a **deny** statement, the packet or fragment is denied.
	• The entry is also applied to non-initial fragments in the following manner. Because non-initial fragments contain only Layer 3 information, only the Layer 3 portion of an access-list entry can be applied. If the Layer 3 portion of the access-list entry matches, and
	  • If the entry is a **permit** statement, the non-initial fragment is permitted.
	  • If the entry is a **deny** statement, the next access-list entry is processed.
	Note The deny statements are handled differently for non-initial fragments versus non-fragmented or initial fragments.

...the **fragments** keyword and all of the access-list entry information matches	The access-list entry is applied only to non-initial fragments. **Note** If the **fragments** keyword is configured for an access-list entry, the Layer 4 information will be ignored for the non-initial fragments.

You should not add the **fragments** keyword to every access-list entry, because the first fragment of the IP packet is considered a non-fragment and is treated independently of the subsequent fragments. Because an initial fragment will not match an access list permit or deny entry that contains the **fragments** keyword, the packet is compared to the next access list entry until it is either permitted or denied by an access list entry that does not contain the **fragments** keyword. Therefore, you may need two access list entries for every deny entry. The first deny entry of the pair will not include the **fragments** keyword, and applies to the initial fragment. The second deny entry of the pair will include the **fragments** keyword and applies to the subsequent fragments. In the cases where there are multiple **deny** access list entries for the same host but with different Layer 4 ports, a single deny access-list entry with the **fragments** keyword for that host is all that has to be added. Thus all the fragments of a packet are handled in the same manner by the access list.

Packet fragments of IP datagrams are considered individual packets and each fragment counts individually as a packet in access-list accounting and access-list violation counts.

Note The **fragments** cannot be configured for an access-list entry that contains any Layer 4 information.

Note Within the scope of ACL processing, Layer 3 information refers to fields located within the IPv4 header; for example, source, destination, protocol. Layer 4 information refers to other data contained beyond the IPv4 header; for example, source and destination ports for TCP or UDP, flags for TCP, type and code for ICMP.

Configuring TTL Matching

You can configure ACLs to match on the TTL value specified in the IPv4 header. You can specify the TTL match condition to be based on a single value, or multiple values.

TTL matching is supported for both ingress and egress ACLs.

Configuration

Use the following steps to configure TTL matching.

```
/* Configure an IPv4 ACL with the TTL parameters */
Router(config)# ipv4 access-list acl-v4
Router(config-ipv4-acl)# 10 deny tcp any any ttl eq 100
Router(config-ipv4-acl)# 20 permit tcp any any ttl range 1 50
Router(config-ipv4-acl)# 30 permit tcp any any ttl neq 100
Router(config-ipv4-acl)# commit
Thu Nov  2 12:22:58.948 IST

/* Attach the IPv4 ACL to the HundredGigE interface */
Router(config)# interface HundredGigE 0/0/0/0
Router(config-if)# ipv4 address 15.1.1.1 255.255.255.0
Router(config-if)# ipv4 access-group acl-v4 ingress
Router(config-if)# commit
```

Running Configuration

Validate your configuration by using the **show run** command.

```
Router(config)# show run
Thu Nov  2 14:01:53.376 IST
Building configuration...
!! IOS XR Configuration 0.0.0
!! Last configuration change at Thu Nov  2 12:22:59 2017 by annseque
!
ipv4 access-list acl-v4
 10 deny tcp any any ttl eq 100
 20 permit tcp any any ttl range 1 50
 30 permit tcp any any ttl neq 100
!
interface HundredGigE 0/0/0/0
 ipv4 address 15.1.1.1 255.255.255.0
 ipv4 access-group acl-v4 ingress
!
```

You have successfully configured TTL matching for IPv4 ACLs.

Understanding IP Access List Logging Messages

Cisco IOS XR software can provide logging messages about packets permitted or denied by a standard IP access list. That is, any packet that matches the access list causes an informational logging message about the packet to be sent to the console. The level of messages logged to the console is controlled by the **logging console** command in global configuration mode.

The first packet that triggers the access list causes an immediate logging message, and subsequent packets are collected over 5-minute intervals before they are displayed or logged. The logging message includes the access list number, whether the packet was permitted or denied, the source IP address of the packet, and the number of packets from that source permitted or denied in the prior 5-minute interval.

However, you can use the { **ipv4 | ipv6** } **access-list log-update threshold** command to set the number of packets that, when they match an access list (and are permitted or denied), cause the system to generate a log message. You might do this to receive log messages more frequently than at 5-minute intervals.

Caution If you set the *update-number* argument to 1, a log message is sent right away, rather than caching it; every packet that matches an access list causes a log message. A setting of 1 is not recommended because the volume of log messages could overwhelm the system.

Even if you use the { **ipv4 | ipv6} access-list log-update threshold** command, the 5-minute timer remains in effect, so each cache is emptied at the end of 5 minutes, regardless of the number of messages in each cache. Regardless of when the log message is sent, the cache is flushed and the count reset to 0 for that message the same way it is when a threshold is not specified.

Note The logging facility might drop some logging message packets if there are too many to be handled or if more than one logging message is handled in 1 second. This behavior prevents the router from using excessive CPU cycles because of too many logging packets. Therefore, the logging facility should not be used as a billing tool or as an accurate source of the number of matches to an access list.

Per Interface Statistics

When binding ACL to interfaces, you can configure ACE drop counts by using the **interface-statistics** keyword in the per-interface mode.

In Cisco 8000 Series Routers, you can allocate up to 8 stats counters per NPU.

This also limits the number of the interface that can support the same ACL in per-interface-stats mode to 8. Additional binding of the same ACL in per-interface-stats mode will be rejected.

Note For a specific direction, all interfaces on a line card using the same ACL must be configured in the same stats mode, if not the subsequent binding will be rejected.

This is true for the bundle interface too. If you add any member to the existing bundle interface with a different stats mode, the binding will be rejected.

Configuration Example

```
Router# interface HundredGigE 0/0/0/0
Router(config-if)#ipv4 address 1.1.1.1 255.255.0.0
Router(config-if)#ipv6 address 2001::1/64
Router(config-if)#ipv4 access-group test ingress interface-statistics
Router(config-if)#commit
```

Verification

To display deny stats on the interface:

```
Router#show access-lists ipv4 test hardware ingress interface
 FourHundredGigE 0/1/0/0 location 0/1/CPU0

ipv6 access-list test
10 permit ipv6 any 200:23::/64
20 deny udp any any (2356 matches)
```