Link Bundling on Cisco 12000 Series Internet Routers

Part Number OL-8696-01, May 30, 2008

Feature History

Release	Modification
12.0(23)S	This feature was introduced on Engine 0, Engine1, and Engine 2 line cards on the Cisco 12000 series Internet router.
12.0(26)S	This feature was introduced on IP Service Engine (ISE/E3) and Engine 4 Plus (E4+) line cards on the Cisco 12000 series Internet router. The following new features were introduced: • Out-of-service support • Bandwidth propagation support
12.0(32)S	Support was added for the following features in a link bundle that consists only of ISE/E3 or E4+ Gigabit Ethernet (GE) member interfaces in a Cisco 12000 series Internet router deployed on the provider edge: • Any Transport over MPLS (AToM: Layer 2 Quality of Service, Ethernet over MPLS—VLAN mode only, and Layer 2 Local Switching) • Stacked VLAN (802.1Q-in-Q) Processing • MAC Address Accounting • Multicast and Multicast VPN (Gigabit Ethernet ISE interfaces only) • Policy-Based Routing • Quality of Service (QoS) • Feature parity on VLAN and Stacked VLAN subinterfaces • Unicast Reverse Path Forwarding (Loose Mode) • VLAN scalability Engine 5 Ingress support was added. VLAN ID-based mode of load-balancing was added. route processor redundancy plus (RPR+) support in link bundles was added.

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Release	Modification
12.0(33)S	Support was added for the following features in an ISE/E3 link bundle that consists of POS or GE member interfaces: • Multicast Egress QoS • QoS hierarchical policing • QoS hierarchical shaping • Unicast Reverse Path Forwarding (Strict Mode) Support was added for Engine 5 (E5) Fast Ethernet member interfaces in an EtherChannel link bundle. Engine 5 Egress support was added so that the following features are now supported in an EtherChannel link bundle that consists of E5 Fast Ethernet or Gigabit Ethernet member interfaces: • Any Transport over MPLS (AToM: Layer 2 Quality of Service, Ethernet over MPLS—VLAN mode only, and Layer 2 Local Switching) • Border Gateway Protocol (BGP) policy accounting • Feature parity on VLAN and Stacked VLAN subinterfaces • Hot Standby Router Protocol (HSRP) • MAC Address Accounting • MPLS VPN • Multicast and Multicast VPN • Policy-Based Routing • Quality of Service (QoS), including: – Multicast Egress QoS – QoS hierarchical policing – QoS hierarchical shaping • Route processor redundancy plus (RPR+) • Sampled and Aggregate NetFlow on input and output interfaces • Stacked VLAN (802.1Q-in-Q) Processing • Unicast Reverse Path Forwarding (Loose and Strict Mode) • VLAN ID-based mode of load-balancing • VLAN scalability Cisco IOS software feature parity between a POS channel that consists of ISE, E4+, E5, or E6 member interfaces and EtherChannel bundles was added. Table 4 lists supported features. Stateful Switchover (SSO) support in link bundles was added.

This feature module describes how to configure and use the Link Bundling feature on Cisco 12000 series Internet routers. This document includes the following sections:

Feature Overview

The Link Bundling feature allows you to group multiple point-to-point links together into one logical link to provide higher bidirectional bandwidth (a bigger pipe), redundancy, and load-balancing between two routers. The following types of link bundling are supported on Cisco 12000 series Internet routers:

- Fast EtherChannel—Used to bundle multiple E5 Fast Ethernet (FE) interfaces.
- Gigabit EtherChannel—Used to bundle multiple Gigabit Ethernet (GE) interfaces.
- POS channel—Used to bundle multiple Packet-over-SONET (POS) interfaces.

Managing Bandwidth

All three link bundling methods on Cisco 12000 series Internet routers provide flexible and incremental bandwidth with link redundancy and greater layer transparency to network applications. You can use link bundles in multiple locations in the same network.

Use link bundling on Cisco 12000 series Internet routers in networks under the following conditions:

- Faster links do not exist
- The next step available for increasing link capacity is expensive
- The operational costs to increase link capacity are high

EtherChannels and POS channels allow you to increase and decrease bandwidth by adding or removing an interface from the link bundle. Also, by incrementally increasing bandwidth, you are no longer dependent on the fixed increases in bandwidth (for example, 1 Gbps, 10 Gbps, and so on) determined by the physical layer technology.

Managing Link Failure

The failure of one link does not necessarily cause a network failure. Traffic is redirected to remaining links within the channel without user intervention. As a result, the availability of a FE, GE, or POS link is increased.

On Cisco 12000 series Internet routers, link bundling is implemented so that a virtual interface is created for each link bundle. You can dynamically add and delete links to the virtual interface. The virtual interface is treated as one interface on which you configure an IP address and other software features used by the link bundle, instead of configuring them on individual GE and POS interfaces.

Packets sent to the link bundle are forwarded on one of the links in the bundle. Load-balancing is supported on all links in a bundle using per-destination load-balancing based on a hash calculated using the source and destination IP addresses in the IP packet. Per-destination load-balancing ensures that packets are delivered in order.

For a description of how to use EtherChannel and POS channel link bundling on Cisco 12000 series Internet routers, see the "Using EtherChannel Link Bundles" section on page 4 and the "Using POS Channel Link Bundles" section on page 4.

Link Bundling Features

Beginning in Cisco IOS Release 12.0(26)S, support for the following features is added to link bundling on Cisco 12000 series Internet routers:

- Out-of-service support—If the minimum bandwidth is not available on a link bundle, the EtherChannel or POS channel are brought down. The link bundle is brought up again when the specified minimum number of links are active.

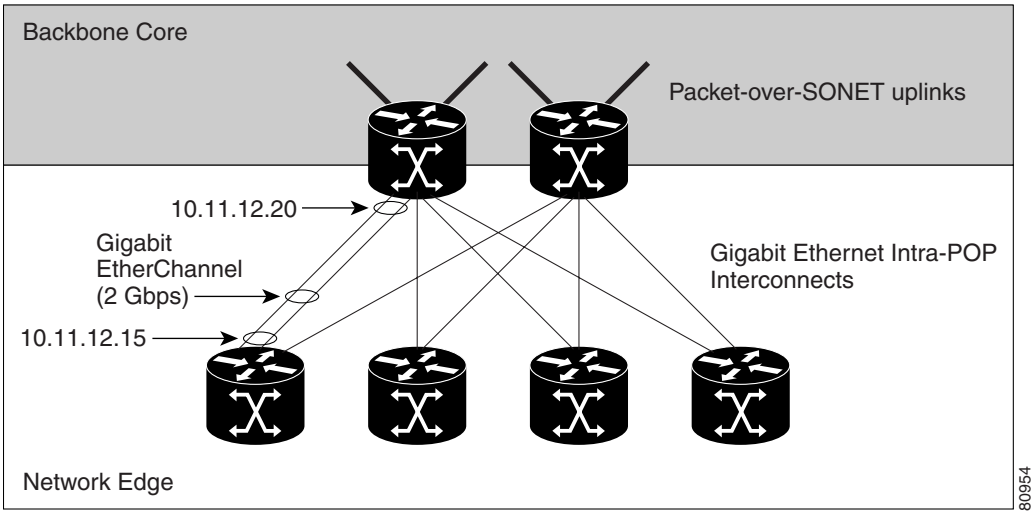
- Bandwidth propagation—In releases earlier than Cisco IOS Release 12.0(33)S, when the bandwidth used on a EtherChannel or POS channel changes, each bandwidth change is propagated, by default, to the upper-layer protocols. You can now (optionally) control the propagation of bandwidth changes and specify a bandwidth threshold so that the total bandwidth of a link bundle is propagated at each change until it exceeds the threshold value.

For a description of how to configure out-of-service support and bandwidth propagation, see the "Configuring Out-of-Service Support" section on page 36 and the "Configuring Bandwidth Propagation" section on page 36.

Using EtherChannel Link Bundles

EtherChannel link bundles are at Layer 2 and use one MAC address and one IP address for all FE or GE interfaces in the bundle. A Fast or Gigabit EtherChannel is used mostly in intra-POP applications to interconnect multiple routers. Figure 1 shows how to aggregate Gigabit Ethernet links into one Gigabit EtherChannel interface in an intra-POP application.

Figure 1 Gigabit EtherChannel Used in an Intra-POP Application



You can also use an EtherChannel in metropolitan area networks for Ethernet aggregation at the network edge. For example, you can use a Gigabit EtherChannel to connect multiple sites that are moving from using 1 Gbps to 10 Gbps throughput. Bandwidth demand grows at different rates in metropolitan network sites, depending on business needs and data traffic patterns. You can, therefore, use Gigabit EtherChannel to incrementally increase bandwidth in 1-Gbps segments.

Using POS Channel Link Bundles

POS channel link bundles are at Layer 2 and use one logical IP interface. You can use POS channel link bundling in intra-POP applications (Figure 2), and in backbone (Figure 3) and peering connections.

For example, if the fiber infrastructure required to support greater transmission speeds does not exist, bundling together multiple POS connections is useful. A POS channel link bundle provides an alternative way to support OC-48, OC-192, or OC-768 transmission speeds.

Figure 2 POS Channel Used in an Intra-POP Application

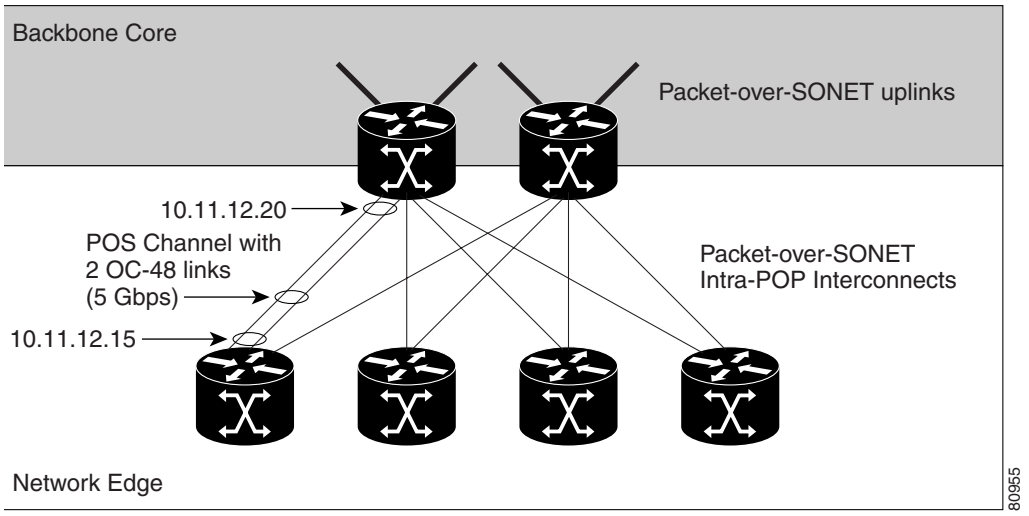
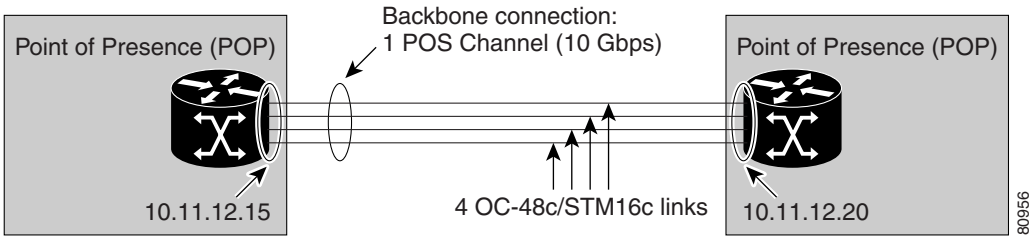


Figure 3 POS Channel Used in a Backbone Application



Link Bundling in a Cisco 12000 Series Internet Router

Link bundling is a capability that must be supported on a system-wide level in a Cisco 12000 series Internet router. The Link Bundling feature requires that each line card in the router recognize an EtherChannel or POS channel bundle as a virtual interface.

The successful flow of data packets into and out of a link bundle consists of the following steps:

1. An EtherChannel or POS channel link bundle is created on a line card or across multiple line cards.
2. An adjacency representing the new bundle is created in the forwarding information base (FIB) table on the route processor (RP) and is forwarded to all the line cards. This adjacency represents a virtual link and has pointers to individual links in the bundle.
3. As incoming data packets are received by the router, line cards route packets to the link bundle as a whole. The ability to route and load balance packets across the bundle depends on whether or not a line card recognizes the new virtual link adjacency. The line card that receives incoming packets and decides how to route them to the link bundle is called the *ingress line card*. The process of making the decision is called *ingress decision support*.

   If the ingress line card:

  - Supports the ingress decision capability, the line card recognizes the virtual adjacency, and properly routes and load balances the packets across the subadjacencies represented by the virtual adjacency. Packets are properly routed and load balanced towards the bundle, and then properly transmitted across the bundle.
  - Does not support the ingress decision capability, the line card routes packets to the virtual adjacency, but does not perform load-balancing across the subadjacencies. Packets are sent across only one link in the bundle. As a result, this link can become saturated and packets can be dropped. For a list of the Cisco 12000 series line cards that support and do not support the ingress decision capability, see the "Restrictions for Link Bundling" section on page 23.

4. When incoming packets are received by the link bundle, the packets are properly routed to the destination interface in the router.

Engine 5 Ingress Support

Starting in Cisco IOS Release 12.0(32)S, EtherChannel bundles support load-balancing across member links for the following combinations of IP and MPLS data streams when an Engine 5 line card is the ingress interface and an EtherChannel port-channel interface is the egress interface in a Cisco 12000 series Internet router. An Engine 5 ingress interface:

- Receives IP packets; a port-channel interface forwards the IP packets.
- Receives IP packets; a port-channel interface encapsulates packets with an MPLS label and forwards the packets.
- Encapsulates packets with an MPLS label; a port-channel interface swaps or replaces the MPLS label and forwards the MPLS packets.
- Receives MPLS packets; a port-channel interface removes the MPLS labels and forwards IP packets.
- Configured for AToM encapsulates incoming packets and transmits them across a pseudowire connection; a port-channel interface decapsulates the packets and transmits the Layer 2 packets.

In these conditions, IP and MPLS packets are load-balanced across the member links in an EtherChannel bundle. For more information about MPLS tag switching, refer to *MPLS/Tag Switching*.

Load-balancing in Cisco 12000 Series Link Bundles

On Cisco 12000 series Internet routers, EtherChannel, and POS channel link bundling provides load-balancing (equal cost) across all active links in the bundle. Load-balancing (also known as Layer 2 load-balancing) is supported on the links using per-destination load-balancing, based on a hash calculated using the source and destination IP addresses in the IP packet. Per-destination load-balancing ensures that packets are delivered in order.

In an EtherChannel or POS channel link bundle, you can only configure interfaces of the same engine and media type. (For more information, see "Line Card Restrictions in Routers on Each Side of a Link Bundle" section on page 24.) Each engine type uses a different hash algorithm to perform load-balancing across member interfaces in a link bundle.

Load-balancing logic is built into the CPU software of lower engine types and into the Layer 3 packet-switching ASIC (PSA) driver modules of higher engine types. Load-balancing logic is stored:

- In the CPU software on Engine 0 and Engine 1 line cards
- On the packet-switching ASIC (PSA) of Engine 2 line cards

- On the ALPHA PSA of IP Service Engine (ISE) line cards
- On the Rx Plus PSA of Engine 4 Plus (E4+) line cards
- On the WAHOO PSAs of Engine 5 (E5) line cards

Note Layer 2 load-balancing is always performed on the ingress line card when a packet is switched.

Equal load-balancing across all links in a bundle occurs only when the source and destination IP addresses in packets vary across a wide range of IP addresses.

Starting in Cisco IOS Release 12.0(32)S, VLAN ID-based load-balancing, is supported. See "VLAN ID-Based Load-balancing" section on page 7 for more information.

VLAN ID-Based Load-balancing

VLAN ID-based load-balancing is supported on the port-channel interface of an EtherChannel bundle that consists of the following member interfaces:

- E5 Fast Ethernet
- ISE (E3) Gigabit Ethernet
- E4+ Gigabit Ethernet
- E5 Gigabit Ethernet

Outgoing traffic is normally equally balanced across all links in a bundle based on the source and destination IP address of transmitted packets. However, VLAN ID-based load-balancing in a link bundle introduces load-balancing based on the VLAN ID of transmitted packets.

When you configure VLAN ID-based load-balancing, all egress traffic with a specified VLAN ID is internally mapped to outgoing member interfaces through which the traffic is transmitted. To switch between VLAN ID-based and per-destination load-balancing, use the **channel-group load-share vlan** command in (port-channel) interface configuration mode.

Use VLAN ID-based load sharing in a link bundle in the following configurations:

- A customer requires VLAN-specific Quality of Service on egress traffic, which cannot be achieved due to hardware limitations when source- and destination-based load-balancing is enabled.
- For Layer 2 traffic or when AToM features are configured on a port-channel interface, Layer 3 parameters, such as source and destination IP address, are not supported. Therefore, we recommend load-balancing based on Layer 2 characteristics.

Note VLAN ID-based load-balancing is effective when there are a large number of (more than 10) VLANs configured on the port-channel interface. When only a few VLANs are configured in an EtherChannel, VLAN ID-based load-balancing is not effective for balancing outgoing traffic across member links.

The VLAN ID-to-interface mapping is performed by assigning the traffic for each VLAN ID according to the load supported on a member interface and the load required by the VLAN. The load required for VLAN traffic is calculated as the bandwidth allocated to the Modified Deficit Round Robin (MDRR) queue. New VLAN traffic is assigned to the member interface transmitting the smallest load. The total

load of egress VLAN traffic in a link bundle is balanced among member interfaces. If a change in the number of active member links available for use occurs, the VLAN ID-to-interface mapping is recalculated.

Software Features Supported on a Link Bundle

Sometimes the software features supported on an Fast Ethernet, Gigabit Ethernet, or POS interface are not supported on the entire link bundle because of engineering restrictions. For example, IPv6 is not supported on a link bundle. Configuring an unsupported feature on an EtherChannel or POS channel link-bundle interface may result in unexpected behavior.

On Cisco 12000 series Engine 0 (E0), E1, and E2 line cards, the minimum set of software features supported across an entire link bundle (port-channel or pos-channel and member interfaces) is:

- IP unicast
- Multiprotocol Label Switching (MPLS)
- MPLS virtual private networks (VPNs)
- MPLS VPN Inter-Autonomous Systems (Inter-AS)
- Weighted Random Early Detection (WRED) and Modified Deficit Round Robin (MDRR) on each member interface

Note Engine 1 and Engine 2 interfaces do not support VLAN configuration in an EtherChannel.

On Cisco 12000 series ISE/E3, E4+, and E5 line cards, the minimum set of software features supported on the port-channel or pos-channel and member interfaces is:

- IP unicast

  Equal-cost load-balancing of IP traffic is performed across all active links in a link bundle.

- VLAN configuration on a link bundle—EtherChannels only

  An EtherChannel interface supports the configuration of VLAN subinterfaces. However, the configuration of stacked (802.1Q-in-Q) processing is only supported on certain EtherChannel interfaces. For more detailed information, see "Stacked VLAN Processing—802.1Q-in-Q" section on page 13.

  For an example of how to configure an EtherChannel that consists of Ethernet VLAN links, see the "Configuring a VLAN EtherChannel" section on page 41.

- Multiprotocol Label Switching

  Equal-cost load-balancing of MPLS traffic is performed across all active links in a link bundle.

- MPLS virtual private networks

  A Layer 3 MPLS VPN configuration is supported on an EtherChannel or POS channel interface that is used in any of the following Provider Edge (PE) router configurations:

  - PE-to-CE (customer edge) connection as a VPN routing and forwarding (VRF) instance
  - PE-to-P (provider core) connection as a core-facing interface

- Quality of Service (QoS) features: shaping, policing, MDRR/WRED, and packet marking
- Access Control Lists (ACLs)
- Named ACLs

- Sampled NetFlow on:
  - Input interfaces only
  - Output interfaces only
  - On both input and output interfaces
- Border Gateway Protocol (BGP) policy accounting
- Hot Standby Router Protocol (HSRP) and Virtual Router Redundancy Protocol (VRRP)—EtherChannels only

Note If the link bundle consists of Engine 5 line cards with different ASIC versions, software features may not be supported in an EtherChannel. For example, stacked VLAN (802.1Q-in-Q) processing is supported in an EtherChannel only if all member interfaces are on SPAs that use the Engine 5 Version 2 FUGU ASIC. The Version 1 GILA ASIC does not support stacked VLAN processing. For information about Engine 5 line card support on specific ASIC versions, refer to *Supported Line Cards for the 12000 Series Routers* in the *Cross-Platform Release Notes for Cisco IOS Release 12.0S*.

Using an EtherChannel for High-Speed Provider Edge Support

In addition to the minimum set of software features described in the "Software Features Supported on a Link Bundle" section on page 8, the following software features are also supported in an EtherChannel that consists of ISE (E3), Engine 4+ (E4+), or Engine 5 (E5) member interfaces in a Cisco 12000 series Internet router that is deployed as a provider edge (PE) router:

- Any Transport over MPLS—Ethernet over MPLS
  - Ethernet over MPLS—VLAN Mode
  - Layer 2 Quality of Service
  - Layer 2 Local Switching
- Stacked VLAN Processing—802.1Q-in-Q
- Unicast Reverse Path Forwarding
- VLAN ID-Based Load-balancing
- Multicast and Multicast VPN
- Policy-Based Routing
- Quality of Service, including: traffic shaping, policing, Modified Deficit Round Robin (MDRR), Weighted Random Early Detection (WRED), packet classification (marking), filtering defined by access control lists (ACLs), and Class of Service (COS) bit mapping
- Route Processor Redundancy Plus
- Stateful Switchover

Any Transport over MPLS—Ethernet over MPLS

The following Any Transport over Multiprotocol Label Switching (AToM)—Ethernet over MPLS (EoMPLS) features are supported only on the port-channel (logical) interface of an EtherChannel bundle that is configured for EoMPLS:

- Ethernet over MPLS—VLAN Mode
- Layer 2 Quality of Service
- Layer 2 Local Switching
- Layer 2 Protocol Tunneling and PDU Filtering

EoMPLS provides the following benefits:

- A tunneling mechanism for Ethernet traffic through an MPLS-enabled Layer 3 core. It encapsulates Ethernet protocol data units (PDUs) inside MPLS packets and using label stacking forwards them across the MPLS network.
- The ability for service providers to offer customers a virtual Ethernet line service or VLAN service using the service provider's existing MPLS backbone.

For more information about how to configure and use EoMPLS, refer to *Any Transport over MPLS*.

Ethernet over MPLS—VLAN Mode

In an MPLS network, the Ethernet over MPLS (EoMPLS) feature enables you to connect two VLAN networks located in different locations, without using bridges, routers, or switches at the VLAN locations. You can enable the MPLS backbone network to accept Layer 2 VLAN traffic by configuring the label edge routers (LERs) at both ends of the MPLS backbone.

In the Link Bundling feature on the Cisco 12000 series Internet router, EoMPLS is supported on the port-channel interface of an EtherChannel bundle that consists of the following member interfaces and only in VLAN mode:

- ISE/Engine 3 Gigabit Ethernet
- Engine 5 Fast Ethernet
- Engine 5 Gigabit Ethernet

You can configure an EtherChannel with EoMPLS on the ingress interface of a PE router in a PE-CE (customer edge) connection or on the egress interface in a PE-P provider-core router connection.

VLAN mode transports Ethernet traffic from a source 802.1Q VLAN to a destination 802.1Q VLAN (including stacked VLAN 802.1Q-in-Q traffic) over a core MPLS network. You must configure Ethernet over MPLS (VLAN mode) on the subinterfaces of member interfaces.

Note EoMPLS is not supported in port mode on an EtherChannel port-channel interface. Port mode allows a frame traveling into an interface to be packed into an MPLS packet and transported over the MPLS backbone to an egress interface. The entire Ethernet frame is transported without the preamble or Frame Check Sequence (FCS) as one packet.

When you configure EoMPLS on a port-channel interface, AToM virtual circuits (VCs) are transparently distributed on the interfaces of the member links in PE-to-P router connections by the AToM control plane, which views the link bundle as one virtual interface. A VC label is allocated on a per-VLAN basis. Because all Ethernet packets are forwarded on the same path for a given VLAN, the egress VLAN ID is used to obtain the Layer 2 adjacency.

On the port-channel interface, EoMPLS also supports the VLAN ID Rewrite feature, which enables you to use VLAN interfaces with different VLAN IDs at both ends of the tunnel.

In an EoMPLS configuration on a port-channel interface, only VLAN ID-based load-balancing is supported.

Layer 2 Quality of Service

On the Cisco 12000 series Internet router, Layer 2 QoS features that are normally supported on Fast or Gigabit Ethernet interfaces (see the "Quality of Service" section on page 18) are supported on the port-channel (Layer 3) interface of a link bundle that is configured for EoMPLS and consists of the following member interfaces:

- ISE/Engine 3 Gigabit Ethernet
- Engine 5 Fast Ethernet
- Engine 5 Gigabit Ethernet

Supported Layer 2 QoS features include:

- Per-class traffic shaping on egress traffic (disposition)
- 2-rate, 3-color Color-blind policer (supported on Cisco 12000 series ISE and E5 Ethernet line cards, based on RFC 2698)

Note The QoS: Color-Aware Policer feature is not supported on a port-channel interface. You can configure policing for EtherChannel traffic only in color-blind mode. The **conform-color** command is not supported.

- Policing and bit marking on ingress traffic (imposition)
- Marking MPLS experimental bits as a policing action, in addition to setting the 802.1p User Priority field (P-bits)
- Mapping and copying the Layer 2 class of service (COS) P-bits to MPLS experimental bits at the ingress interface
- Mapping and copying MPLS experimental bits to Layer 2 CoS P-bits at the egress interface
- Setting Layer 2 CoS P-bits based on the VLAN ID at the egress interface

Policing and shaping Layer 2 VPN traffic at the MPLS imposition and disposition interfaces allows a service provider to offer service level agreements (SLAs) to customers in terms that include bandwidth, delay, jitter, and packet-loss guarantees in an EtherChannel connection. At imposition, Ethernet QoS markers are mapped to MPLS experimental bits. The traffic can be classified by the MPLS experimental bit then policed and shaped on provider interfaces.

For traffic traversing an EtherChannel, Modified Deficit Round Robin (MDRR) Congestion management and Weighted Random Early Detection (WRED) congestion avoidance are supported for MPLS packets with Layer 2 VPN payloads. Because packet queuing characteristics vary among Cisco 12000 series line cards, MDRR and WRED configurations can vary with the line card combinations used for MPLS imposition and disposition interfaces.

The following restrictions apply to Layer 2 QoS features configured on a port-channel interface:

- Per-class traffic shaping is not supported in a QoS policy attached to an ingress port-channel interface that performs EoMPLS label imposition and disposition.
- MDRR and WRED on ToFab queues are not supported on a port-channel interface that performs EoMPLS label imposition.

For a complete description and configuration information of the Layer 2 QoS features supported on Cisco 12000 series ISE and E5 interfaces, refer to *Any Transport over MPLS (AToM): Layer 2 QoS (Quality of Service)*.

Layer 2 Local Switching

The Layer 2 Local Switching feature allows you to switch Layer 2 data between two interfaces of the same type (for example, Ethernet to Ethernet VLAN) or between interfaces of different types (for example, ATM to Ethernet) on the same router.

In the Link Bundling feature on the Cisco 12000 series Internet router, Layer 2 Local Switching is supported on the port-channel interface of an EtherChannel bundle that is configured for EoMPLS and consists of the following member interfaces:

- ISE/Engine 3 Gigabit Ethernet
- Engine 5 Fast Ethernet
- Engine 5 Gigabit Ethernet

In addition, Layer 2 local switching is only supported for “like-to-like” switching between two member interfaces or subinterfaces of the same type as follows:

- Gigabit Ethernet to Gigabit Ethernet interface
- 802.1Q VLAN to 802.1Q VLAN subinterface
- Stacked VLAN (802.1Q-in-Q) to 802.1Q-in-Q subinterface

Apart from “like-to-like” switching, ATM-Ethernet interworking mode (bridged mode) for link bundling is also supported.

Note Only bridged mode is supported for link bundling. Routed mode is not supported.

The interfaces can reside on the same line card or on two different cards. During these kinds of like-to-like switching, the Layer 2 address is used, not any Layer 3 address. Additionally, same-port local switching allows you to switch Layer 2 data between two circuits on the same interface. For more information, refer to *Layer 2 Local Switching*.

In an EtherChannel, local switching involves switching Ethernet packets between customer edge (CE) routers that are on the same side of the connection as the Cisco 12000 series Internet (PE) router. Because the packet switching is performed using fake VC labels in a way similar to AToM label imposition, the VC label cannot be used for load-balancing. For load-balancing, the hash index is calculated using the VLAN ID in EoMPLS VLAN mode. (EoMPLS port mode is not supported for Layer 2 local switching.) The hash index is used to select the adjacency and is programmed into the hardware.

Layer 2 Protocol Tunneling and PDU Filtering

In the Link Bundling feature on the Cisco 12000 series Internet router, EoMPLS supports Layer 2 protocol tunneling (L2PT) and Layer 2 PDU filtering on the port-channel interface of an EtherChannel bundle that consists of the following member interfaces:

- ISE/Engine 3 Gigabit Ethernet
- Engine 5 Fast Ethernet
- Engine 5 Gigabit Ethernet

Layer 2 protocol tunneling allows service providers to carry traffic from multiple customers across a core network, and maintain the VLAN and Layer 2 protocol configurations of each customer without impacting the traffic of other customers. The Transparent Layer 2 Protocol Tunneling feature allows Layer 2 protocol data units (PDUs) to be tunneled across the core network without being interpreted and processed by intermediary network devices. Layer 2 PDU filtering allows a service provider to specify

which Layer 2 PDUs are to be dropped at an ingress interface on a provider edge (PE) router. Transparent Layer 2 Protocol Tunneling and PDU filtering provide an enhanced feature set for service providers that transmit customer VLAN traffic from metro Ethernet VPNs across an MPLS core network.

Transparent Layer 2 protocol tunneling and PDU filtering are intended for use on provider edge (PE) routers in an MPLS-enabled service-provider core network.

For more information, refer to *Transparent Layer 2 Protocol Tunneling and PDU Filtering*.

Stacked VLAN Processing—802.1Q-in-Q

Stacked VLAN processing is supported only on the port-channel interface of an EtherChannel bundle that consists of the following member interfaces:

- ISE (E3) 4-port Gigabit Ethernet
- E5 (FUGU ASIC-based) Fast Ethernet
- E5 (FUGU ASIC-based) Gigabit Ethernet

The Stacked VLAN Processing feature supports the encapsulation of IEEE 802.1Q VLAN tags within a second layer of 802.1Q tag on provider edge (PE) routers to allow service providers to use a single VLAN to support customers who have multiple VLANs. The core service-provider network carries traffic with double-tagged, stacked VLAN (802.1Q-in-Q) headers of multiple customers while maintaining the VLAN and Layer 2 protocol configurations of each customer and without impacting the traffic of other customers. The Stacked VLAN Processing feature preserves VLAN IDs and keeps traffic in different customer VLANs segregated.

To allow a subinterface in an EtherChannel bundle on a PE-POP Cisco 12000 series Internet router to connect to a third-party PE-CLE switch that supports an EtherType value that is different from the default Cisco EtherType value (0x8100), enter the **dot1q tunneling ethertype** command on the port-channel interface. (The EtherType value supported on Cisco routers and switches is 0x8100. The networking devices of some other vendors support EtherType 0x9100.)

After you enter this command, only stacked VLAN packets with the specified EtherType value in the SP-VLAN tag of the packet header are received on subinterfaces in the link bundle. The new EtherType value is used in the SP-VLAN tag of all stacked VLAN packets sent from subinterfaces in the EtherChannel bundle to the PE-CLE switch, except if EoMPLS is configured on the port-channel interface. If EoMPLS is configured, all traffic received on an EoMPLS member interface (or subinterface) is sent to the PE-CLE switch as it was received from the peer PE router, without the new EtherType value.

For more information about how to configure and use stacked VLAN processing, refer to *Stacked VLAN Processing*.

Feature Parity on VLAN and Stacked VLAN Member Interfaces

VLAN and Stacked VLAN subinterfaces on member interfaces support all software features that are supported on a port-channel interface of an EtherChannel bundle that consists of the following member interfaces:

- E5 Fast Ethernet
- ISE (E3) Gigabit Ethernet
- E4+ Gigabit Ethernet
- E5 Gigabit Ethernet

Some of the software features supported both on the EtherChannel interface and member VLAN and stacked VLAN subinterfaces include:

- Access control lists (ACLs)
- BGP policy-map accounting (only on ingress port-channel and subinterfaces)
- Hot Standby Router Protocol (HSRP) and Virtual Router Redundancy Protocol (VRRP)
- MPLS VPN Interautonomous Systems
- Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN)

MAC Address Accounting

MAC address accounting is supported only on the port-channel interface of an EtherChannel bundle that consists of the following member interfaces:

- E5 Fast Ethernet
- ISE (E3) Gigabit Ethernet
- E4+, Gigabit Ethernet
- E5 Gigabit Ethernet

The MAC address accounting feature provides accounting information for IP traffic based on the source and destination MAC addresses on LAN interfaces. This feature calculates the total packet and byte counts for the EtherChannel that receives or sends IP packets to or from a unique MAC address. It also records a timestamp for the last packet received or sent.

To configure a port-channel interface for IP accounting based on the MAC address, enter the **ip accounting mac-address** {**input** | **output**} command in interface configuration mode, where:

- **input** performs accounting based on the source MAC address on received packets.
- **output** performs accounting based on the destination MAC address on received packets.

To display the MAC accounting information for an EtherChannel, use the **show interfaces mac** command in privileged EXEC mode.

Note An EtherChannel that consists of Modular Gigabit Ethernet (E4+) member interfaces supports either byte or packet accounting, but not both.

Multicast and Multicast VPN

Multicast routing protocols and multicast VPN are supported on the 802.1Q VLAN and stacked VLAN 802.1Q-in-Q subinterfaces and on the port-channel interface of an EtherChannel bundle that consists of the following member interfaces:

- E5 Fast Ethernet
- ISE 4-port Gigabit Ethernet
- E5 Gigabit Ethernet

Multicast Routing Protocols

You can enable multicast routing protocols on the port-channel interface and 802.1Q VLAN and 802.1Q-in-Q subinterfaces of an EtherChannel bundle, including Internet Group Management Protocol (IGMP), Protocol-Independent Multicast (PIM), Protocol Independent Multicast dense mode

(PIM-DM), PIM sparse mode (PIM-SM), source specific multicast (SSM), Multicast Distributed Switching (MDS), Distance Vector Multicast Routing Protocol (DVMRP), and Cisco Group Management Protocol (CGMP).

For information about how to use and configure multicast routing protocols, refer to:

- P1C: Cisco IOS IP and IP Routing Configuration Guide
- FC: Cisco IOS Release 12.0 Configuration Fundamentals Configuration Guide
- FR: Cisco IOS Release 12.0 Configuration Fundamentals Command Reference
- *Multicast Distributed Switching*
- *Multicast Source Discovery Protocol*

Multicast Fast-path Forwarding

Multicast fast-path forwarding allows hardware-based fast forwarding of IPv4 multicast traffic, resulting in high throughputs and performance. Packet forwarding is performed in the hardware switching engine instead of on the line card CPU. For more information, refer to *Fast-Path Multicast Forwarding on Cisco 12000 Series Engine 2 and ISE Line Cards*.

Multicast VPN

Multicast VPN provides the ability to support the multicast feature over a Layer 3 VPN. A multicast VPN allows an enterprise to transparently interconnect its private network across the network backbone of a service provider. Because MPLS VPNs support only unicast traffic connectivity, deploying the Multicast VPN feature in conjunction with MPLS VPN allows service providers to offer both unicast and multicast connectivity to MPLS VPN customers.

The Multicast VPN—IP Multicast Support for MPLS VPNs feature allows a service provider to configure and support multicast traffic in an MPLS Virtual Private Network (VPN) environment. This feature supports routing and forwarding of multicast packets for each individual VPN routing and forwarding (VRF) instance, and it also provides a mechanism to transport VPN multicast packets across the service provider backbone. For more information about this feature, refer to *Multicast VPN—IP Multicast Support for MPLS VPNs*.

Multicast QoS

Quality-of-service (QoS) features, which are supported on Fast Ethernet or Gigabit member interfaces and VLAN subinterfaces, are also supported in the egress direction on an EtherChannel interface configured for multicast traffic. For more information about this feature, refer to *Multicast Egress QoS Support on Cisco 12000 Series Router, Integrated Services Engine (ISE) Line Cards.* For more information on specific QoS features and the EtherChannels on which they are supported, see the "Quality of Service" section on page 18.

Multicast Configuration Commands

You must configure all multicast and multicast VPN commands on the port-channel interface associated with an EtherChannel after you enter the **interface port-channel** command. The configuration of multicast commands is not supported on:

- Member interfaces
- Port-channel interfaces of bundles that have one or more non-ISE or non-E5 member interfaces

The multicast and multicast VPN control plane and protocols that you configure on a port-channel interface are not aware of the member interfaces. All packets transmitted through member interfaces appear to the multicast control plane as packets sent through the logical EtherChannel interface. All multicast **show** commands that you enter on the control-plane level display multicast information for the port-channel (logical) interface.

Load-balancing for multicast traffic is performed using a hash algorithm that takes group information in (*,G) entries and (S,G) entries. The outgoing member link is selected using the source and destination IP addresses. If you enable VLAN ID-based load-balancing, multicast traffic is forwarded based on the VLAN ID of transmitted packets.

Policy-Based Routing

Policy-based routing (PBR) is supported on the port-channel interface of an EtherChannel bundle that consists of the following member interfaces:

- E5 Fast Ethernet
- ISE Gigabit Ethernet
- E4+ Gigabit Ethernet
- E5 Gigabit Ethernet

You can also configure a routing policy for individual Fast Ethernet and Gigabit Ethernet member subinterfaces.

Policy-based routing provides a flexible means of routing packets by allowing you to configure a defined policy for traffic flows, lessening reliance on routes derived from routing protocols. You can set up PBR as a way to route packets based on configured policies. For example, you can implement routing policies to allow or deny paths based on the identity of a particular end system or an application protocol.

You can configure a unique routing policy for any of the following:

- Port-channel interface of an EtherChannel bundle
- An individual subinterface configured on the port-channel interface
- Multiple subinterfaces configured on an EtherChannel port-channel interface

A policy contains one or more route maps. Each route map has one or more statements that specify the required matching criteria and actions. For example, a matching statement can be an access control list (ACL). If the matching criteria are met, the action statements are executed. An action statement can contain a routing action or a quality of service (QoS) action. The routing action determines the output interfaces for a packet or the next hop. The QoS action may be to set the type of service (ToS) or IP precedence parameter to a specific value.

For information about configuring policy-based routing, refer to *Configuring Policy-Based Routing*.

Unicast Reverse Path Forwarding

The Unicast Reverse Path Forwarding (Unicast RPF) feature is supported in an EtherChannel bundle as follows:

- In an EtherChannel bundle that consists only of E5 Fast Ethernet, ISE Gigabit Ethernet, or E5 Gigabit Ethernet member interfaces, Unicast RPF is supported in loose and strict modes on the main port-channel interface, VLAN subinterfaces, and stacked VLAN subinterfaces.
- In an EtherChannel bundle that consists only of E4+ Modular Gigabit Ethernet member interfaces, Unicast RPF is supported only in loose mode on the main port-channel interface.

The Unicast Reverse Path Forwarding Loose Mode feature provides a scalable anti-spoofing mechanism for use in multihome network configuration. This mechanism is effective in service-provider networks on routers that have multiple links to multiple Internet service providers (ISPs), on an ISP-to-ISP network edge.

Unicast RPF (loose or strict mode) provides a quick reaction mechanism for dropping network traffic on the basis of either the source or destination IP address. Network administrators can use this configuration as a tool for mitigating denial of service (DoS) and distributed denial of service (DDoS) attacks.

Verifying Source IPv4 Addresses

The difference between loose and strict checking modes is as follows:

- Loose (exist-only) checking mode only verifies that a source IPv4 address exists in the routing table and that a valid return path through any interface exists in the Forwarding Information Base (FIB).
- Strict checking mode verifies that the source IPv4 address of an IPv4 packet exists in the routing table and that the source IPv4 address is reachable by a path through the input interface (the interface on which the packet enters the router), such as a link-bundle member interface.

To provide ISPs with a DDoS resistance tool on the ISP-to-ISP edge of a network, Unicast RPF is enhanced from its original strict mode implementation to check the source addresses of each ingress packet without regard for the specific interface on which it was received.

You can enable Unicast RPF in strict or loose mode on an EtherChannel interface or subinterface. For information about enabling Unicast RPF, refer to *Unicast Reverse Path Forwarding Loose Mode* or *Unicast Reverse Path Forwarding in Strict Mode on the Cisco 12000 Series Internet Router*.

VLAN Scalability

Enhanced VLAN scalability is only supported on the port-channel interface of an EtherChannel bundle that consists of the following member interfaces:

- E5 Fast Ethernet
- ISE 4-port Gigabit Ethernet
- E5 Gigabit Ethernet

In Cisco IOS Release 12.0(31)S and earlier releases, when you create a subinterface on a member interface of an EtherChannel bundle, a subinterface is also created on all other member interfaces in the bundle. The following equation shows the total number of software data structures (known as IDBs) used for tracking Cisco IOS interfaces and interface status when you configure N number of subinterfaces in a link bundle:

Number of IDBs created = (1 + M) x N

Where:

- M is the total number of member interfaces in the bundle
- 1 is added for the IDB used for the subinterface created for the port-channel (logical) interface
- N is the number of subinterfaces created

For example, if a link bundle consists of 4 member interfaces and you configure 2 subinterfaces on member interfaces, the total number of IDBs created is 10.

Note In the forwarding information base (FIB) table, the total number of IDBs created is included in the total number of IDBs created.

The equation shows how the number of subinterfaces supported on an EtherChannel bundle, and therefore the number of supported VLANs, is limited due to the increased amount of route processor memory used by the IDBs.

For this reason, in Cisco IOS Release 12.0(31)S and earlier releases, the number of VLANs supported in an EtherChannel bundle that consists of 4-port Gigabit Ethernet ISE member interfaces is 300. However, starting in Cisco IOS Release 12.0(32)S and later releases, a software enhancement allows you to configure up to 1000 VLANs on the supported Gigabit Ethernet member interfaces in a link bundle. Engine 5 Fast Ethernet member interfaces are supported starting in Cisco IOS Release 12.0(33)S.

In addition, when you increase the number of VLANs on the member interfaces of an EtherChannel, the performance of VLAN load-balancing and data transmission depends on the percentage of ternary content addressable memory (TCAM) allocated for VLANs on each line card, whose interfaces belong to the link bundle. You can maximize the VLAN TCAM size allocated to each ISE/E3 Gigabit Ethernet subinterface by using the **hw-module slot linkbundle-tcam-scalability** command (see the "Maximizing VLAN TCAM to Support VLAN Scalability" section on page 34). When you enter this command, the Layer 2 TCAM regions on an ISE (E3) line card are recarved to support 1K of VLAN traffic on each subinterface in a link bundle.

Note The **hw-module slot linkbundle-tcam-scalability** command is a required command for an ISE line card.

Quality of Service

The Quality-of-Service (QoS) features described in this section are supported only on the port-channel interface of an EtherChannel bundle that consists of the following member interfaces:

- E5 Fast Ethernet
- ISE 4-port Gigabit Ethernet
- E4+ Modular Gigabit Ethernet
- E5 Gigabit Ethernet

Certain QoS features supported on Ethernet interfaces are also supported when you assign these interfaces to an EtherChannel bundle. See Table 1, Table 2, and Table 3 for a list of supported QoS features.

The following restrictions apply when you use QoS features in an EtherChannel bundle:

- On ISE 4-port Gigabit Ethernet member links, QoS features are configured on the port-channel interface and supported on main Gigabit Ethernet interfaces and on subinterfaces when VLAN ID-based load-balancing is enabled. Main interfaces support only QoS packet classification and marking. QoS packet classification and marking are supported only in the ingress direction on main and subinterfaces. QoS features are supported on a port-channel interface only in the ingress and egress direction for multicast traffic.
- On E4+ Modular Gigabit Ethernet member links, QoS features are configured on the port-channel interface and supported only on main Gigabit Ethernet interfaces. QoS features are not supported on subinterfaces.
- On E5 Fast Ethernet and Gigabit Ethernet member links, QoS features are configured on the port-channel interface and supported on main Gigabit Ethernet interfaces and on subterfaces when VLAN ID-based load-balancing is enabled. Main interfaces support only QoS packet classification and marking. QoS packet classification and marking are supported only in the ingress direction on main and subinterfaces.

- The **match** VLAN statement in class-map configuration mode is not supported.
- In an EtherChannel bundle, traffic policing configured on ingress interfaces works properly only if incoming traffic is transmitted from another network device that uses VLAN ID-based load-balancing.

To configure QoS features, you must use the modular Quality-of-Service command-line (MQC) interface. For information, refer to:

- *Cisco IOS Quality of Service Solutions Configuration Guide*, Release 12.3
- *Modular Quality of Service Command-Line Interface*

For E3 link bundling interfaces, QoS policies are not attached on secondary RP in SSO redundancy mode after one of the following:

- Router reload or bootup
- Secondary RP reload
- Link bundle member link flaps

After the switchover, remove and reattach QoS policies to enable them again. Also, switch to RPR or RPR+ redundancy mode toavoid secondary RP crash.

Table 1 QoS Features Supported on 4-port Gigabit Ethernet ISE Interfaces in an EtherChannel

QoS Command or Feature in Ingress and Egress Directions	4-port Gigabit Ethernet ISE Interface	4-port Gigabit Ethernet ISE VLAN 802.1Q Subinterface	Stacked VLAN (802.1Q-in-Q) Subinterface
Committed access rate (CAR) using **rate-limit**	Not supported	Supported	Supported
Modified Deficit Round Robin (MDRR)	Not supported	Not supported: ingress Supported: egress	Not supported: ingress Supported: egress
Weighted Random Early Detection (WRED)	Not supported: ingress Not supported: egress	Not supported: ingress Supported: egress	Not supported: ingress Supported: egress
set cos (egress only)	Not supported	Supported	Supported
set discard-class (ingress only)	Supported	Supported	Supported
set dscp	Supported	Supported	Supported
set ip precedence	Supported	Supported	Supported
set mpls experimental	Supported	Supported	Supported
set qos-group (ingress only)	Supported	Supported	Supported
Shaping	Not supported: ingress Not supported: egress	Not supported: ingress Supported: egress	Not supported: ingress Supported: egress
Hierarchical shaping	Not supported: ingress Not supported: egress	Supported: egress only	Supported: egress only
Hierarchical policing	Not supported: ingress Not supported: egress	Supported: ingress Supported: egress	Supported: ingress Supported: egress

Table 2 QoS Features Supported on Modular Gigabit Ethernet Interfaces in an EtherChannel

QoS Command or Feature in Ingress and Egress Directions	Modular Gigabit Ethernet Interface	Modular Gigabit Ethernet VLAN Subinterface[1]
Committed access rate (CAR) using **rate-limit**	Not supported	Not supported
Modified Deficit Round Robin (MDRR)	Not supported	Not supported
Weighted Random Early Detection (WRED)	Not supported	Not supported
set cos (egress only)	Not supported	Not supported
set discard-class (ingress only)	Supported	Not supported
set dscp	Supported	Not supported
set ip precedence	Supported	Not supported
set mpls experimental	Supported	Not supported
set qos-group (ingress only)	Supported	Not supported
Shaping	Not supported	Not supported
Hierarchical shaping	Not supported	Not supported
Hierarchical policing	Not supported	Not supported

1. In an EtherChannel bundle, modular Gigabit Ethernet (E4+) member subinterfaces do not support any of the QoS features normally supported on a modular Gigabit Ethernet (E4+) subinterface.

Table 3 QoS Features Supported on Engine 5 Fast and Gigabit Ethernet Interfaces in an EtherChannel

QoS Command or Feature in Ingress and Egress Directions	E5 Fast Ethernet or Gigabit Ethernet Interface	E5 Fast Ethernet or Gigabit Ethernet VLAN 802.1Q Subinterface	E5 Stacked VLAN (802.1Q-in-Q) Subinterface
Committed access rate (CAR) using **rate-limit**	Not supported	Supported	Supported
Modified Deficit Round Robin (MDRR)	Not supported	Not supported: ingress Supported: egress	Not supported: ingress Supported: egress
Weighted Random Early Detection (WRED)	Not supported: ingress Not supported: egress	Not supported: ingress Supported: egress	Not supported: ingress Supported: egress
set cos (egress only)	Not supported	Supported	Supported
set discard-class (ingress only)	Supported: ingress	Supported	Supported
set dscp	Supported	Supported	Supported
set ip precedence	Supported	Supported	Supported
set mpls experimental	Supported	Supported	Supported
set qos-group (ingress only)	Supported	Supported	Supported
Shaping	Not supported: ingress Not supported: egress	Not supported: ingress Supported: egress	Not supported: ingress Supported: egress

QoS Command or Feature in Ingress and Egress Directions	E5 Fast Ethernet or Gigabit Ethernet Interface	E5 Fast Ethernet or Gigabit Ethernet VLAN 802.1Q Subinterface	E5 Stacked VLAN (802.1Q-in-Q) Subinterface
Hierarchical shaping	Not supported: ingress Not supported: egress	Supported: egress only	Supported: egress only
Hierarchical policing	Not supported: ingress Not supported: egress	Supported: ingress Supported: egress	Supported: ingress Supported: egress

Feature Parity on POS Channel Bundles

Starting in Cisco IOS Release 12.0(33)S, the same level of support for IOS software features exists on a POS channel bundle that consists of ISE, E4+, E5, and E6 member interfaces as on an EtherChannel link bundle. For a description of the supported software features, see the "Software Features Supported on a Link Bundle" section on page 8 and the "Using an EtherChannel for High-Speed Provider Edge Support" section on page 9.

Table 4 summarizes the support for each Cisco IOS software feature in a POS channel link-bundle interface according to the engine type of member interfaces.

Table 4 IOS Software Features Supported on a POS Channel Interface by Engine Type

IOS Software Feature or QoS Command	ISE/E3 POS Channel Main Interface	E4+ POS Channel Main Interface	E5 POS Channel Main Interface	E6 POS Channel Main Interface
IPv4 forwarding	Supported	Supported	Supported	Supported
MPLS forwarding	Supported	Supported	Supported	Supported
MPLS VPNs	Supported	Supported	Supported	Supported
MPLS VPN Inter-Autonomous Systems (Inter-AS)	Supported	Supported	Supported	Supported
Multicast forwarding	Supported	Not supported	Supported	Not supported
Multicast QoS	Supported	Not supported	Supported	Not supported
Multicast VPN	Supported	Not supported	Supported	Not supported
Policy-based routing	Supported	Supported	Supported	Supported
set cos (egress only)	Supported	Supported	Supported	Supported
set discard-class (ingress only)	Supported	Supported	Supported	Supported
set dscp	Supported	Supported	Supported	Supported
set ip precedence	Supported	Supported	Supported	Supported
set mpls experimental	Supported	Supported	Supported	Supported
set qos-group (ingress only)	Supported	Supported	Supported	Supported
MDRR/WRED	Not supported	Not supported	Not supported	Not supported
Policing	Not supported	Not supported	Not supported	Not supported
Shaping (egress interface)	Not supported	Not supported	Not supported	Not supported
Access Control Lists (ACLs): input and output interfaces	Supported	Supported	Supported	Supported

IOS Software Feature (continued)or QoS Command	ISE/E3 POS Channel Main Interface	E4+ POS Channel Main Interface	E5 POS Channel Main Interface	E6 POS Channel Main Interface
Border Gateway Protocol (BGP) policy accounting	Supported	Supported	Supported	Supported
Sampled NetFlow	Supported	Supported	Supported	Supported
Stateful Switchover (SSO)	Supported	Supported	Supported	Supported
Unicast RPF in loose mode	Supported	Supported	Supported	Supported
Unicast RPF in strict mode	Supported	Not supported	Supported	Not supported

Route Processor Redundancy Plus

Both EtherChannel and POS channel bundles support the Route Processor Redundancy Plus (RPR+) feature. The standby route processor (RP) maintains an updated configuration of the link bundle for use during the switchover.

When two RPs are installed in a Cisco 12000 series Internet router chassis, one RP acts as the active RP, and the other acts as a backup (or standby) RP. If the active RP fails or is removed from the system, the standby RP detects the failure and initiates a switchover. During a switchover, the standby RP assumes control of the router, connects with the network interfaces, and activates the local network management interface and system console.

Using the RPR+ feature, the standby RP is fully initialized and configured, which allows RPR+ to dramatically shorten the switchover time if the active RP fails or if a manual switchover is performed. Because both the startup configuration and the running configuration are continually synchronized from the active to the standby RP, line cards are not reset during a switchover. The state of the interfaces does not change during switchover, so that neighboring routers do not detect a link flap (that is, the link does not go down and back up). For more information, refer to *Route Processor Redundancy Plus for the Cisco 12000 Series Internet Router*.

Stateful Switchover

Both EtherChannel and POS channel bundles also support the Stateful Switchover (SSO) feature. Like the RPR+ feature, SSO is one link in a chain of Cisco IOS redundancy features designed to provide progressively higher system and network availability.

In a Cisco 12000 series Internet router that support dual RPs, SSO takes advantage of RP redundancy to synchronize critical state information between the active and standby RP. Following an initial synchronization between the two processors, SSO dynamically maintains RP state information between them.

SSO mode provides all the functionality of RPR+ in that Cisco IOS software is fully initialized on the standby RP. In addition, SSO supports synchronization of line card, protocol, and application state information between RPs for supported features and protocols (a “hot standby”).

A switchover from the active to the standby processor occurs when the active RP fails, is removed from the networking device, or is manually taken down for maintenance. Because SSO is used with the Cisco Nonstop Forwarding (NSF) feature, Cisco NSF allows for the forwarding of data packets to continue along known routes while the routing protocol information is being restored following a switchover. With Cisco NSF, peer networking devices do not experience routing flaps, thereby reducing loss of service outages for customers.

Unlike the RPR+ feature, the last known FIB information is used by the backup RP when it takes over the active RP function. All link bundle activity (for example, active-to-passive member transition, VLAN load-balancing, bandwidth changes) is synchronized in the standby RP. During the switchover, packet forwarding in link bundles remains uninterruptred.

For information about the differences between the RPR+ and SSO redundancy modes and how to configure SSO, refer to *Stateful Switchover*.

Benefits of Link Bundling

EtherChannel and POS channel link bundling on Cisco 12000 series Internet routers provide the following benefits:

- Flexible, incremental bandwidth
- Transparency to network applications
- Support for IP unicast and MPLS traffic
- Load-balancing (equal cost) across all active links in the bundle
- Redundancy: if there is a failure of an individual GE or POS link, the traffic flow through the channel is evenly distributed across the available links.
- Interoperability with link bundling implementations in other Cisco and OEM routers and switches.
- Out-of-service support: an EtherChannel or POS channel is brought down if the minimum number of GE or POS links are not up.
- Bandwidth propagation support: bandwidth changes in an EtherChannel or POS channel can be (optionally) propagated to the upper-layer protocols until the amount of bandwidth required in the link bundle exceeds a specified threshold.

Restrictions for Link Bundling

Line Cards Supported on the Cisco 12000 Router

EtherChannel and POS channel link bundling are supported on the following line cards in Cisco 12000 series Internet routers:

- Engine 0:
  - 4-port OC-3c/STM-1c POS/SDH line card
  - 1-port OC-12c/STM-4c POS/SDH line card
- Engine 1:
  - 1-port Gigabit Ethernet line card
- Engine 2:
  - 3-port Gigabit Ethernet line card
  - 4-port OC-3c/STM-1c POS/SDH line card
  - 8-port OC-3c/STM-1c POS/SDH line card
  - 16-port OC-3c/STM-1c POS/SDH line card
  - 4-port OC-12c/STM-4c POS/SDH line card
  - 1-port OC-48c/STM-16c POS/SDH line card
- IP Service Engine (ISE):
  - 4-port Gigabit Ethernet ISE line card

  - 4-port OC-3c/STM-1c POS/SDH ISE line card
  - 8-port OC-3c/STM-1c POS/SDH ISE line card
  - 16-port OC-3c/STM-1c POS/SDH ISE line card
  - 4-port OC-12c/STM-4c POS/SDH ISE line card
  - 1-port OC-48c/STM-16c POS/SDH ISE line card
- Engine 4 Plus (E4+):
  - Modular Gigabit Ethernet line card
  - 1-port 10-Gigabit Ethernet line card
  - 4-port OC-48c/STM-16c POS/SDH line card
  - 1-port OC-192c/STM-64c POS/SDH line card
- Engine 5 shared port adapters (SPAs):
  - 1-port 10-Gigabit Ethernet
  - 2-port Gigabit Ethernet
  - 5-port Gigabit Ethernet
  - 10-port Gigabit Ethernet
  - 8-port Fast Ethernet
  - 8-port 10/100 Ethernet
  - 4-port OC-3/STM4 POS
  - 8-port OC-3/STM4 POS
  - 2-port OC-12/STM4 POS
  - 4-port OC-12/STM4 POS
  - 8-port OC-12/STM4 POS
  - 2-port OC-48/STM16 POS/RPR
  - 1-port OC-192/STM64 POS/RPR
- Engine 5 SPA Interface Processors (SIPs):
  - 10G Engine 5 SPA Interface Processor (12000-SIP-600)
  - 2.5G multiservice engine SPA Interface Processor (12000-SIP-401)
  - 5G multiservice engine SPA Interface Processor (12000-SIP-501)
  - 10G multiservice engine SPA Interface Processor (12000-SIP-601)
- Engine 6:
  - 8-port OC-48/STM16-c POS line card
  - 2-port OC-192 POS line card

Line Card Restrictions in Routers on Each Side of a Link Bundle

In an EtherChannel or POS channel link bundle, the following restrictions apply:

- You can only configure interfaces of the same media type, engine type, and port speed on the router at each end of a connection. For example, you can only add an Engine 2 OC-12 POS interface to a POS channel that consists of Engine 2 OC-12 POS interfaces. You cannot add an Engine 2 OC-12 POS interface to a POS channel that consists of Engine 3 (ISE) OC-12 POS or Engine 2 OC-3 POS interfaces, or to an EtherChannel that consists of Engine 5 GE interfaces.
- You can configure interfaces of the same media type and engine type that are on different line cards, different shared port adapters (SPAs), and different SPA interface processors (SIPs). For example:
  - You can configure a POS channel that consists of Engine 2 POS interfaces on line cards in slots 2, 3, and 4 in a router.
  - You can configure an EtherChannel that consists of Engine 5 GE interfaces on SPAs in different jackets cards on different SIPs, such as 12000-SIP-600 and 12000-SIP-601.

- You can configure an EtherChannel or POS channel with a certain media type and engine type (for example, Engine 3/ISE Gigabit Ethernet) on one router, and configure the link bundle on the remote router with the same media but a different engine type (for example, Engine 5 Gigabit Ethernet).
- Although you can create an EtherChannel that consists of Engine 5 member interfaces on SPAs with different ASIC versions (Version 1 GILA and Version 2 FUGU), software features are supported across the link bundle (on port-channel and member interfaces) only if they are supported on both ASIC versions.

  For example, stacked VLAN (802.1Q-in-Q) processing is supported in a Engine 5 Gigabit EtherChannel only if all member interfaces are on SPAs that use the Engine 5 Version 2 FUGU ASIC. The Version 1 GILA ASIC does not support stacked VLAN processing.

  For information about which Engine 5 line cards support the different ASIC versions, refer to *Supported Line Cards for the 12000 Series Routers* in the *Cross-Platform Release Notes for Cisco IOS Release 12.0S*.

Symmetric Configuration on Both Sides of a Link Bundle

In both EtherChannel and POS channel link bundles, the Link Aggregation Control Protocol (LACP) for signalling and the 802.3ad protocol for automatic negotiation of the channel are not supported. This means that in order for the channel between two routers to be active, you must disable signaling on switches (such as the Cisco 6500/7600 Series) in the channel, and configure the switches in ON mode.

In addition, an EtherChannel or POS channel between two adjacent routers must be configured with the same number of members (interfaces) on the router at each end of the channel. This is required for an EtherChannel or POS channel interface to function correctly and for the link status to come up.

Ingress Decision Support

For an EtherChannel or POS channel to operate correctly with equal cost load-balancing, the Link Bundling feature requires that all line cards in a Cisco 12000 series Internet router support the ingress decision capability (described in the "Link Bundling in a Cisco 12000 Series Internet Router" section on page 5).

Only the following Cisco 12000 series line cards support ingress decision capability:

- Engine 0 Asynchronous Transfer Mode (ATM) line cards
- Engine 0 Channelized DS3/E3 line cards
- Engine 0 Dynamic Packet Transport (DPT) line cards
- Engine 0 Packet-over-SONET line cards
- Engine 1 Fast Ethernet line cards
- Engine 1 Gigabit Ethernet line cards
- Engine 2 8-port OC-3/STM-1 ATM line cards
- Engine 2 Dynamic Packet Transport (DPT) line cards
- Engine 2 Gigabit Ethernet line cards
- Engine 2 Packet-over-SONET line cards
- IP Service Engine (ISE) line cards:
  - 4-port Gigabit Ethernet ISE line card
  - 4-port OC-3c/STM-1c POS/SDH ISE line card
  - 8-port OC-3c/STM-1c POS/SDH ISE line card
  - 16-port OC-3c/STM-1c POS/SDH ISE line card

  - 4-port OC-12c/STM-4c POS/SDH ISE line card
  - 1-port OC-48c/STM-16c POS/SDH ISE line card
- Engine 6/4+ line cards
- Engine 5 line cards

The following Cisco 12000 series line cards do not support ingress decision capability:

- Engine 0 Channelized DS1/E1, OC-3, and T3 line cards
- Engine 2 Asynchronous Transfer Mode (ATM) line cards, except for the 8-port OC-3/STM-1 ATM line card
- Engine 4 line cards

Engine 5 Ingress and Egress Support

Starting in Cisco IOS Release 12.0(32)S, Engine 5 line cards are supported as the ingress interface when an EtherChannel port-channel interface is the egress interface in a Cisco 12000 series Internet router. In this case, an EtherChannel bundle supports load-balancing for IP and MPLS packets across member links for the following combinations of IP and MPLS data streams. An Engine 5 ingress interface:

- Receives IP packets; a port-channel interface forwards the IP packets.
- Receives IP packets; a port-channel interface encapsulates packets with an MPLS label and forwards the packets.
- Encapsulates packets with an MPLS label; a port-channel interface swaps or replaces the MPLS label and forwards the MPLS packets.
- Receives MPLS packets; a port-channel interface removes the MPLS labels and forwards IP packets.
- Configured for AToM encapsulates incoming packets and transmits them across a pseudowire connection; a port-channel interface decapsulates the packets and transmits the Layer 2 packets.

For more information about MPLS tag switching, refer to *MPLS/Tag Switching*.

Starting in Cisco IOS Release 12.0(33)S, Engine 5 line cards are also supported as the egress interface on which you can configure a virtual interface (EtherChannel or POS channel) for a link bundle. For a list of supported Engine 5 interfaces, see Line Cards Supported on the Cisco 12000 Router, page 23.

Cisco IOS Command Restrictions

- Layer 1/Layer 2 commands are physical interface-specific and are supported on an EtherChannel or POS channel interface, for example, **crc 32**, **keepalive**, **clock**, and **negotiation** commands.
- Layer 3 commands are channel-specific and are not supported on a member interface; for example, **ip address**, **mpls**, **acl**, and **mtu** commands.

EtherChannel Restrictions

- Up to 8 FE or GE links are supported per EtherChannel bundle. Up to 16 EtherChannel bundles are supported per Cisco 12000 series Internet router.
- The Fast or Gigabit Ethernet ports that you bundle together must be of the same engine type. For example, you can bundle together supported Engine 1 line cards to form a Gigabit EtherChannel, or you can bundle Gigabit Ethernet ports on supported Engine 2 line cards to form a Gigabit EtherChannel. However, you cannot combine Engine 1 Gigabit Ethernet ports with Engine 2 Gigabit Ethernet ports in a Gigabit EtherChannel.

Link bundles that consist of Fast Ethernet interfaces are supported only on Engine 5 line cards, starting in Cisco IOS Release 12.0(33)S. You cannot combine ISE (Engine 3) ports with Engine 5 Fast Ethernet ports in a Fast EtherChannel.

- MAC Address—An EtherChannel is configured with the MAC address of the first active member (FE or GE link). All other members are configured with the MAC address of the port-channel interface. The static MAC address on the port-channel interface is propagated to all member interfaces. If the first active member:
  - Is removed from the link bundle, the MAC address of the second active member is assigned to the EtherChannel interface.
  - Interface goes down, Cisco IOS software automatically changes the interface from active member to passive member status. The EtherChannel remains configured with the MAC address of the first active member although it is now passive. The interface is not removed from the channel. When the interface comes back up, the software automatically changes the interface back to active member status.

  We do not recommend using static ARP and static routes, such as IP route 1.1.1.1 255.255.255.0 gig/1/1/0.
- Engine 5 ASICs—Software features may not be supported in an EtherChannel if the link bundle consists of Engine 5 line cards with different ASIC versions. For example, stacked VLAN (802.1Q-in-Q) processing is supported in a Gigabit EtherChannel only if all member interfaces are on SPAs that use the Engine 5 Version 2 FUGU ASIC. The Version 1 GILA ASIC does not support stacked VLAN processing.

  For information about Engine 5 line card support for specific ASIC versions, refer to *Supported Line Cards for the 12000 Series Routers* in the *Cross-Platform Release Notes for Cisco IOS Release 12.0S*.
- Fast EtherChannel bundles—In an EtherChannel bundle that consists of Fast Ethernet links, only Engine 5 (E5) Fast Ethernet member interfaces are supported.

POS Channel Restrictions

- Up to 8 POS links are supported per POS channel bundle. Up to 16 POS channel bundles are supported per Cisco 12000 series Internet router.
- The POS ports that you bundle together must be of the same engine type. For example, you can bundle together POS ports on supported Engine 0 line cards to form a POS channel, or you can bundle POS ports on supported Engine 2 line cards to form a POS channel. However, you cannot combine Engine 0 POS ports with Engine 2 POS ports in a POS channel.
- In a POS channel, only HDLC encapsulation is supported.

Load-Balancing Restrictions

- The hash algorithm used for load-balancing by each Cisco 12000 series engine type may not result in complete load-balancing for all IP address patterns.

EoMPLS Restrictions

- AToM EoMPLS features (see the "Any Transport over MPLS—Ethernet over MPLS" section on page 9) are supported only in VLAN mode (802.1Q VLAN or stacked VLAN 802.1Q-in-802.1Q) on the port-channel interface of an EtherChannel bundle. Port mode is not supported.
- AToM EoMPLS features are not supported in a POS channel link bundle.

- In an EtherChannel bundle that consists of E5 member interfaces, Layer 2 PDU filtering (L2PDU) and Layer 2 protocol tunneling (L2PT) are only supported on FUGU ASIC-based SPA interfaces; these features are not supported on GILA ASIC-based SPAs.

VLAN Scalability Restrictions

- On the port-channel interface of an EtherChannel bundle that consists of E5 Fast Ethernet, ISE 4-port Gigabit Ethernet, or E5 Gigabit Ethernet member interfaces, VLAN load-balancing and data transmission may be limited by the percentage of TCAM allocated for VLANs on ISE line cards. To increase the VLAN TCAM size, use the **hw-module slot linkbundle-tcam-scalability** command, as described in the "Maximizing VLAN TCAM to Support VLAN Scalability" section on page 34.

MPLS Carrier Supporting Carrier Restrictions

- The MPLS Carrier Supporting Carrier (CsC) feature is not supported on an EtherChannel or POS channel interface.

Related Features and Technologies

- Metropolitan area network (MAN)
- Multiprotocol Label Switching (MPLS)
- Virtual Private Networks (VPNs)

Related Documents

- *Cisco IOS Switching Services Configuration Guide*, Release 12.3
- *Cisco IOS Switching Services Command Reference*, Release 12.3
- *Network Protocols Command Reference, Part 1,* Release 11.3
- *Fast EtherChannel Feature Module*

Supported Platforms

- Cisco 12000 series Internet routers

Determining Platform Support Through Cisco Feature Navigator

Cisco IOS software is packaged in feature sets that are supported on specific platforms. To obtain updated information on platform support for this feature, access Cisco Feature Navigator. Cisco Feature Navigator dynamically updates as new platform support is added for a feature.

Cisco Feature Navigator is a web-based tool that enables you to determine which Cisco IOS software images support a specific set of features. You can search by feature or release. Under the release section, you can compare releases to display both the features unique to each software release and the features in common.

To access Cisco Feature Navigator, you must have an account on Cisco.com. If you forgot or lost your account information, send a blank e-mail to cco-locksmith@cisco.com. An automatic check verifies that your e-mail address is registered with Cisco.com. If the check is successful, account details with a new random password are e-mailed to you. Qualified users can establish an account on Cisco.com at:

http://www.cisco.com/register

For the most current information, go to the Cisco Feature Navigator home page at:

http://www.cisco.com/go/fn

Availability of Cisco IOS Software Images

Platform support for particular Cisco IOS software releases is dependent on the availability of the software images for those platforms. Software images for some platforms may be deferred, delayed, or changed without notice.

Supported Standards, MIBs, and RFCs

Standards

No new or modified standards are supported by this feature.

MIBs

- BGP4-MIB
- CISCO-BGP-POLICY-ACCOUNTING-MIB
- CISCO-BGP4-MIB
- CISCO-C12000-IF-HC-COUNTERS-MIB
- CISCO-CAR-MIB
- CISCO-CLASS-BASED-QOS-MIB
- CISCO-ENHANCED-WRED-MIB
- CISCO-HSRP-MIB
- CISCO-IETF-IP-FORWARD-MIB
- CISCO-IETF-IP-MIB
- CISCO-IF-EXTENSION-MIB
- CISCO-IP-STAT-MIB
- CISCO-IPMROUTE-MIB
- CISCO-LAG-MIB
- CISCO-OSPF-MIB
- CISCO-PSA-MICROCODE-MIB
- CISCO-QUEUE-MIB
- CISCO-VLAN-IFTABLE-RELATIONSHIP-MIB
- ETHERLIKE-MIB
- IEEE8023-LAG-MIB
- IF-MIB
- MPL-VPN-MIB
- MPLS-LDP-MIB
- OSPF-MIB
- RMON-MIB

To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator at:

http://tools.cisco.com/ITDIT/MIBS/servility/index

If Cisco MIB Locator does not support the MIB information that you need, you can view supported MIBs and download MIBs from the Cisco MIBs page at:

http://www.cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

To access Cisco MIB Locator, you must have an account on Cisco.com. If you forgot or lost your account information, send a blank e-mail to cco-locksmith@cisco.com. An automatic check verifies that your e-mail address is registered with Cisco.com. If the check is successful, account details with a new random password are e-mailed to you. Qualified users can establish an account on Cisco.com at:

http://www.cisco.com/register

RFCs

No new or modified RFCs are supported by this feature.

Configuration Tasks

Configuring the Link Bundling (EtherChannel and POS channel) feature on Cisco 12000 series Internet routers consists of the following steps:

1. For an EtherChannel, create a port-channel interface; for a POS channel, create a pos-channel interface. Then assign an IP address.
2. Assign a Fast Ethernet (FE) or Gigabit Ethernet (GE) interface to the port-channel interface or a Packet-over-SONET (POS) interface to the pos-channel interface.
3. Repeat Step 2 to add an additional GE or POS interface to the link bundle.
4. Repeat Steps 1 to 3 to configure the EtherChannel or POS channel on the router at the other end of the channel.

After you configure an EtherChannel or POS channel, you can configure the out-of-service support and bandwidth propagation features on the link bundle interface.

See the following sections for configuration tasks for the Link Bundling feature. Each task in the list is identified as either optional or required.

- Configuring a Port-Channel Interface, page 31 (required)
- Configuring a POS-Channel Interface, page 32 (required)
- Adding a Fast Ethernet or Gigabit Ethernet Interface, page 33 (required)
- Adding a Packet-over-SONET Interface, page 33 (required)
- Removing an Ethernet or Packet-over-SONET Interface from a Link Bundle, page 35 (optional)
- Configuring Out-of-Service Support, page 36 (optional)
- Configuring Bandwidth Propagation, page 36 (optional)
- Verifying an EtherChannel, page 38 (optional)
- Verifying a POS Channel, page 38 (optional)

For information on other configuration tasks for EtherChannel and POS channel link bundling, refer to the Gigabit Ethernet and Packet-over-SONET sections in the “Configuring Interfaces” chapter of the *Configuration Fundamentals Configuration Guide*.

Configuring a Port-Channel Interface

You must configure a port-channel (logical) interface for each EtherChannel link bundle on the routers at each end of the channel (see the "Configuring an EtherChannel" section on page 39).

To configure a port-channel interface for an EtherChannel, perform the following steps beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface port-channel channel-number`	Creates the port-channel (logical) interface to be used for the EtherChannel and enters interface configuration mode. The valid values for *channel-number* are 1 to 16.
Step 2	`Router(config-if)# ip address ip-address mask`	Assigns an IP address and subnet mask to the EtherChannel.
Step 3	`Router(config-if)# mac address ieee-address`	(Optional) Assigns a static MAC address to the EtherChannel.
Step 4	`Router(config-if)# channel-group bandwidth control-propagation`	(Optional) Enables the automatic propagation of bandwidth changes to upper-layer protocols for the bandwidth threshold specified by the **threshold** *threshold-number* parameter.
Step 5	`Router(config-if)# channel-group bandwidth threshold threshold-number`	(Optional) Specifies the maximum number of active member interfaces allowed in order for the total bandwidth used in the active members of an EtherChannel to be propagated to upper-layer protocols each time there is a change in bandwidth. When a member interface is brought up and the number of active links exceeds the threshold number, the aggregate bandwidth of the active members is not propagated. When the number of active members becomes one more than the threshold value, the aggregate bandwidth of all member interfaces (both active and passive) in the EtherChannel is propagated to upper-layer protocols. Note that the **channel-group bandwidth threshold** *threshold-number* command is valid only after you enter the **channel-group bandwidth control-propagation** command. Also, this value is not valid and a bandwidth change is not propagated if the EtherChannel is down because the minimum number of active member interfaces configured with the **channel-group minimum active** command are not operational.
Step 6	`Router(config-if)# channel-group minimum active link-number`	(Optional) Configures the minimum number of active members (GE links) that must be active in order for the EtherChannel to be operational. The valid values for *link-number* are from 1 to 8.
Step 7	`Router(config-if)# channel-group load-share vlan`	(Optional) Configures load-balancing across member interfaces based on the VLAN ID of transmitted packets.
Step 8	`Router(config-if)# ios-command`	(Optional) Enables other supported interface commands for the software features supported across the entire bundle (see the "Restrictions for Link Bundling" section on page 23).
Step 9	`Router(config-if)# end`	Exits from interface configuration mode.

Configuring a POS-Channel Interface

You must configure a pos-channel (logical) interface for each POS channel link bundle on the routers at each end of the POS channel (see the "Configuring a POS Channel" section on page 41).

To configure a pos-channel interface for a POS channel, perform the following steps beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface pos-channel channel-number`	Creates the port-channel (logical) interface to be used for the POS channel and enters interface configuration mode. The valid values for *channel-number* are 1 to 16.
Step 2	`Router(config-if)# ip address ip-address mask`	Assigns an IP address and subnet mask to the POS channel.
Step 3	`Router(config-if)# channel-group bandwidth control-propagation`	(Optional) Enables the automatic propagation of bandwidth changes to upper-layer protocols for the bandwidth threshold specified by the **threshold** *threshold-number* parameter.
Step 4	`Router(config-if)# channel-group bandwidth threshold threshold-number`	(Optional) Specifies the maximum number of active member interfaces allowed in order for the total bandwidth used in the active members of a POS channel to be propagated to upper-layer protocols each time there is a change in bandwidth. When a member interface goes up and the number of active links exceeds the threshold number, the aggregate bandwidth of the active members is not propagated. When the number of active members becomes one more than the threshold value, the aggregate bandwidth of all member interfaces (both active and passive) in the POS channel is propagated to upper-layer protocols. Note that the **channel-group bandwidth threshold** *threshold-number* command is valid only after you enter the **channel-group bandwidth control-propagation** command. Also, this value is not valid and a bandwidth change is not propagated if the POS channel is down because the minimum number of active member interfaces configured with the **channel-group minimum active** command are not up.
Step 5	`Router(config-if)# channel-group minimum active link-number`	(Optional) Configures the minimum number of active members (POS links) that must be active in order for the POS channel to be up. The valid values for *link-number* are from 1 to 8.
Step 6	`Router(config-if)# ios-command`	(Optional) Enables other supported interface commands for the software features supported across the entire bundle (see the "Restrictions for Link Bundling" section on page 23).
Step 7	`Router(config-if)# end`	Exits from interface configuration mode.

Adding a Fast Ethernet or Gigabit Ethernet Interface

After you configure a port-channel interface on the router at one end of an EtherChannel, you can add up to 8 Fast Ethernet or Gigabit Ethernet interfaces to the EtherChannel group. The interfaces you add to the port-channel must be of the same engine number and media type. For example, a Gigabit EtherChannel can consist only of all Engine 1 GE interfaces or all Engine 2 GE interfaces. The interfaces you add to the port-channel can, however, belong to line cards in different slots.

You must add the same number of members (FE or GE interfaces) to the port-channel logical interface on the router at each end of an EtherChannel (see Configuring an EtherChannel, page 39).

To add a Fast Ethernet or Gigabit Ethernet interface to an EtherChannel bundle, perform the following steps beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface gigabitethernet` *slot/port* `Router(config)# interface fastethernet` *slot/port*	Creates or modifies an existing Fast Ethernet or Gigabit Ethernet interface by specifying the Ethernet line card, subslot (if available), and port number and then enters interface configuration mode.

Step 2	`Router(config-if)# channel-group` *channel-number*
	
	`Command will clear some config: IP address(es), loopback`
	`  Manually remove other configs`
		Assigns the Ethernet interface to the EtherChannel associated with the specified channel number. The valid values for *channel-number* are 1 to 16.

Step 3	`Continue? [yes]: yes`	(Optional) Enter **yes** at the command prompt to configure the Ethernet interface as a member of the port-channel group. The interface's IP address and loopback configuration are deleted.
Step 4	`Router(config-if)# exit`	Exits interface configuration mode. Repeat Step 1 through Step 4 to add up to eight FE or GE interfaces to the EtherChannel bundle.
Step 5	`Router(config-if)# end`	Exits interface configuration mode when you finish configuring the EtherChannel.

Adding a Packet-over-SONET Interface

After you configure a pos-channel interface on the router at one end of a POS channel, you can add up to 8 Packet-over-SONET interfaces to the POS channel group. The interfaces you add to the POS channel must be of the same engine number and media type. For example, a POS channel can consist only of all Engine 0 POS interfaces or all Engine 2 POS interfaces. The interfaces you add can belong to POS line cards in different slots.

You must add the same number of members (POS interfaces) to the pos-channel logical interface on the router at each end of a POS channel (see the "Configuring a POS Channel" section on page 41).

To add a Packet-over-SONET (POS) interface to a POS channel bundle, perform the following steps beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface pos slot/port`	Creates or modifies an existing Packet-over-SONET interface by specifying the line-card slot, subslot (if available), and port number and then enters interface configuration mode.

Step 2	`Router(config-if)# channel-group channel-number`
	
	`Command will clear some config: IP address(es), loopback`
	`  Manually remove other configs`
		Assigns the POS interface to the POS channel associated with the specified channel number. The valid values for *channel-number* are 1 to 16.

Step 3	`Continue? [yes]: yes`	(Optional) Enter **yes** at the command prompt to configure the Packet-over-SONET interface as a member of the pos-channel group. The interface's IP address and loopback configuration are deleted.
Step 4	`Router(config-if)# exit`	Exits interface configuration mode. Repeat Step 1 through Step 4 to add up to 8 POS interfaces to the POS channel bundle.
Step 5	`Router(config-if)# end`	Exits interface configuration mode when you finish configuring the POS channel.

Maximizing VLAN TCAM to Support VLAN Scalability

As you increase the number of VLANs configured on a port-channel interface (see VLAN Scalability, page 17), the performance of VLAN load-balancing and data transmission in an EtherChannel depends on the percentage of TCAM allocated for VLANs on each Fast Ethernet o r Gigabit Ethernet line card whose interfaces belong to the link bundle.

To display the amount of TCAM allocated for Cisco IOS features on an Ethernet line card, enter the **show controllers frfab alpha tcam carve** command.

To increase the VLAN TCAM size so that a maximum of 1K of TCAM is allocated to process VLAN traffic on each member subinterface, perform the following steps starting in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# hw-module slot number linkbundle-tcam-scalability`	Increases VLAN TCAM size on the line card so that 1K of TCAM is allocated to each VLAN subinterface used in an EtherChannel link bundle. Other TCAM regions are recarved accordingly.
Step 2	`Router(config)# microcode reload slot-number`	Reloads the software and microcode on the line card so that the newly configured TCAM region sizes take effect. **Note** You must enter the **microcode reload** command only one time on an ISE line card, and only if you reconfigure TCAM regions on the line card. For example, if you add a new member interface to the EtherChannel after you reconfigure VLAN TCAM and reload the microcode, you do not have to reload the microcode a second time. After you enter the **microcode reload** command, the line card is reset. As a result, traffic forwarding is interrupted. The control protocols and interfaces are down until the line card reset is complete.

Removing an Ethernet or Packet-over-SONET Interface from a Link Bundle

To remove a Fast Ethernet or Gigabit Ethernet interface from an EtherChannel bundle or a Packet-over-SONET interface from a POS channel bundle, perform the following steps beginning in global configuration mode:

	Command	Purpose

Step 1	`Router(config)# interface fastethernet slot/port`
	or
	`Router(config)# interface gigabitethernet slot/port`
	or
	`Router(config)# interface pos slot/port`
		Specifies a Fast Ethernet, Gigabit Ethernet or Packet-over-SONET interface and enters interface configuration mode.

Step 2	`Router(config-if)# no channel-group channel-number`	Removes the FE, GE, or POS interface from an EtherChannel or POS channel.
Step 3	`Router(config-if)# end`	Exits interface configuration mode.

Note If an interface goes down in an EtherChannel or POS channel, the Cisco IOS software automatically changes the FE, GE, or POS interface from active member to passive member status. The interface is not removed from the channel. When the interface comes back up, the software automatically changes the interface back to active member status.

To monitor the status of an EtherChannel, use the **show interfaces port-channel** EXEC command. To monitor the status of a POS channel interface, use the **show interfaces pos-channel** command.

Configuring Out-of-Service Support

After you configure an EtherChannel (see the "Configuring a Port-Channel Interface" section on page 31) or a POS channel (see the "Configuring a POS-Channel Interface" section on page 32), you can specify the minimum number of active member interfaces required to be up and active for the link bundle to stay up or to come up if it is down. This is called out-of-service support and is an optional task.

Configure out-of-service support when you use link bundles that consist of two or more member interfaces and want to avoid overdriving the link bundle interface if a specified amount of bandwidth is not needed in the link bundle. The amount of bandwidth used by a link bundle is the combined amount of default bandwidth on each of its member interfaces.

You can specify a new value for the amount of bandwidth required for a link bundle by specifying the minimum number of active member links that must be up for the link bundle to be up. When a minimum number of member interfaces is not up, the link bundle interface goes down. The link bundle comes up from being out-of-service as soon as the required minimum number of member links become active.

To configure out-of-service support for an EtherChannel or POS channel bundle, perform the following steps beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface port-channel` *channel-number* or `Router(config)# interface pos-channel` *channel-number*	Specifies an EtherChannel or POS channel interface and enters interface configuration mode.
Step 2	`Router(config-if)# channel-group minimum active` *link-number*	Specifies the minimum number of active member links that must be up in order for the link bundle to stay up. The default is that one member interface must be up for the link bundle to stay up.
Step 3	`Router(config-if)# exit`	Exits interface configuration mode.

Configuring Bandwidth Propagation

After you configure an EtherChannel (see the "Configuring a Port-Channel Interface" section on page 31) or a POS channel (see the "Configuring a POS-Channel Interface" section on page 32), you can also specify the upper bandwidth threshold to use for propagating bandwidth changes to upper-layer protocols. By default, at each change in bandwidth in a link bundle, the combined amount of bandwidth used on all active member links is propagated.

A bandwidth change in a link bundle occurs when any of the following events occur:

- A new, active member interface is added or a member interface is removed.
- An active member interface goes down or a member interface that is down comes up.

The bandwidth threshold is specified according to the number of active member interfaces in the link bundle. When the required number of active member interfaces is less than or equal to the specified threshold number, the total amount of bandwidth used in the link bundle is propagated to upper-layer protocols at each bandwidth change. As soon as the number of active member links becomes greater than the specified threshold number, bandwidth changes are no longer propagated.

In addition, bandwidth changes are not propagated if the link bundle goes down because the number of active member interfaces is less than the configured minimum number of active member links required (see Configuring Out-of-Service Support).

Note The **bandwidth** command is supported on an EtherChannel or POS channel interface, but is not supported on a member interface in a link bundle.

To configure an upper bandwidth threshold to use for propagating bandwidth changes in an EtherChannel or POS channel bundle to upper-layer protocols, perform the following steps beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface port-channel` *channel-number* or `Router(config)# interface pos-channel` *channel-number*	Specifies an EtherChannel or POS channel interface and enters interface configuration mode.
Step 2	`Router(config-if)# channel-group bandwidth control-propagation`	Enables the automatic propagation of bandwidth changes to upper-layer protocols for the bandwidth threshold specified in Step 3.
Step 3	`Router(config-if)# channel-group bandwidth threshold` *threshold-number*	Specifies the maximum number of active member interfaces allowed in order for the total bandwidth used in the active members of a link bundle to be propagated to upper-layer protocols each time there is a change in bandwidth. When a member interface goes up and the number of active links exceeds the threshold number, the aggregate bandwidth of the active members is not propagated. When the number of active members becomes one more than the threshold value, the aggregate bandwidth of all member interfaces (both active and passive) in the bundle is propagated to upper-layer protocols. Note that the **channel-group bandwidth threshold** *threshold-number* command is valid only after you enter the **channel-group bandwidth control-propagation** command. Also, this value is not valid and a bandwidth change is not propagated if the link bundle is down because the minimum number of active member interfaces configured with the **channel-group minimum active** command are not up.
Step 4	`Router(config-if)# exit`	Exits interface configuration mode.

Verifying an EtherChannel

To monitor the status of an EtherChannel, use the **show interfaces port-channel** command in privileged EXEC mode. The following output is for a Gigabit EtherChannel with three GE interfaces. All interfaces are up and therefore appear as active members of the channel. If one of the active interfaces goes down, it would be listed as a passive member. The status of a Gigabit EtherChannel is up if it has at least one active member interface.

```
Router# show interfaces port-channel 1
Port-channel1 is up, line protocol is up
  Hardware is GEChannel, address is 0050.2ac6.9581 (bia 0000.0000.0000)
  Internet address is 22.1.0.2/16
  MTU 1500 bytes, BW 3000000 Kbit, DLY 10 usec, rely 255/255, load 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
    No. of active members in this channel: 3
        Member 0 : GigabitEthernet3/1 , Full-duplex, 1000Mb/s
        Member 1 : GigabitEthernet3/2 , Full-duplex, 1000Mb/s
        Member 2 : GigabitEthernet1/2 , Full-duplex, 1000Mb/s
    No. of passive members in this channel: 0
  Last input 00:00:01, output 00:00:01, output hang never
  Last clearing of "show interface" counters 3d15h
  Queueing strategy: fifo
  Output queue 0/120, 0 drops; input queue 0/225, 0 drops
  30 second input rate 1425032000 bits/sec, 1038111 packets/sec
  30 second output rate 0 bits/sec, 0 packets/sec
     328903597021 packets input, 56454340092292 bytes, 0 no buffer
     Received 50815 broadcasts, 0 runts, 0 giants, 0 throttles
     528238 input errors, 0 CRC, 0 frame, 528238 overrun, 0 ignored
     0 watchdog, 0 multicast, 0 pause input
     128365 packets output, 9409520 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier, 0 pause output
     0 output buffer failures, 0 output buffers swapped out
```

Verifying a POS Channel

To monitor the status of a POS channel, use the **show interfaces pos-channel** command in privileged EXEC mode. The following output is for a POS channel with three POS interfaces.

- Two of the interfaces are up, and appear as active members of the channel.
- One POS interface is down, and is listed as a passive member.

If an active member interface goes down, it is shown in the list of passive members. L

ewise, when a passive member comes up, it appears in the active member list. If the POS channel has at least one active member interface, the status of the POS channel is up.

```
Router# show interfaces pos-channel 1
Pos-channel1 is up, line protocol is up
  Hardware is POSChannel
  Internet address is 41.1.0.1/16
  MTU 4470 bytes, BW 1244000 Kbit, DLY 100 usec, rely 255/255, load 236/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
    No. of active members in this channel: 2
        Member 0 : POS5/0
        Member 1 : POS2/3
```

```
  No. of passive members in this channel: 1
      Member 0 : POS5/1
Last input 00:00:01, output 00:00:03, output hang never
Last clearing of "show interface" counters 3d15h
Queueing strategy: fifo
Output queue 0/80, 3665649311 drops; input queue 0/150, 0 drops
30 second input rate 0 bits/sec, 0 packets/sec
30 second output rate 1168138000 bits/sec, 627497 packets/sec
   192649 packets input, 12073574 bytes, 0 no buffer
   Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
   0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
   197631584356 packets output, 46098596464843 bytes, 0 underruns
   0 output errors, 0 collisions, 0 interface resets
   0 output buffer failures, 0 output buffers swapped out
   0 carrier transitions
```

Configuration Examples

This section provides the following configuration examples:

Configuring an EtherChannel

The following is a sample configuration of an EtherChannel between two adjacent routers, in which three Gigabit Ethernet interfaces on each router are configured in the link bundle.

```
Router1# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(config)# interface port-channel 1
Router1(config-if)# ip address 22.1.0.1 255.255.0.0
Router1(config-if)# exit
Router1(config)# interface gigabitethernet4/1
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
  Manually remove other configs

Continue? [yes]: yes
GigabitEthernet4/1 added as member-1 to port-channel1
GigabitEthernet4/1, cleared IP address and loopback mode

Router1(config)# interface gigabitethernet4/2
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
  Manually remove other configs

Continue? [yes]: yes
GigabitEthernet4/2 added as member-2 to port-channel1
GigabitEthernet4/2, cleared IP address and loopback mode
```

```
Router1(config)# interface gigabitethernet5/2
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
  Manually remove other configs.

Continue? [yes]: yes
GigabitEthernet5/2 added as member-3 to port-channel1
GigabitEthernet4/1, cleared IP address and loopback mode

Router1(config-if)# exit

Router2# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router2(config)# interface port-channel 1
Router2(config-if)# ip address 22.1.0.2 255.255.0.0
Router2(config-if)# exit
Router2(config)# interface gigabitethernet3/1
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
  Manually remove other configs.

Continue? [yes]: yes
GigabitEthernet3/1 added as member-1 to port-channel1
GigabitEthernet3/1, cleared IP address and loopback mode

Router2(config)# interface gigabitethernet3/2
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
  Manually remove other configs.

Continue? [yes]: yes
GigabitEthernet3/2 added as member-2 to port-channel1
GigabitEthernet3/2, cleared IP address and loopback mode

Router2(config)# interface gigabitethernet1/2
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
  Manually remove other configs.

Continue? [yes]: yes
GigabitEthernet1/2 added as member-3 to port-channel1
GigabitEthernet1/2, cleared IP address and loopback mode

Router2(config-if)# exit
```

The following example shows how to verify EtherChannel connectivity by pinging each router.

```
Router1# ping 22.1.0.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 22.1.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms

Router2# ping 22.1.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 22.1.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
```

Configuring a VLAN EtherChannel

The following shows a sample configuration of an EtherChannel that consists of two Ethernet 802.1q VLAN links. Bandwidth changes in Gigabit EtherChannel 6 are propagated to upper-layer protocols only when two or more member interfaces are up and active.

```
Router1# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(config)# interface port-channel 6
Router1(config-if)# channel-group minimum active 2
Router1(config-if)# no channel-group bandwidth control-propagation
Router1(config-if)# exit
Router1(config)# interface port-channel 6.1
Router1(config-if)# encapsulation dot1Q 1
Router1(config-if)# ip address 21.1.6.7 255.255.255.0
Router1(config-if)# exit
Router1(config)# interface port-channel 6.3
Router1(config-if)# encapsulation dot1Q 2
Router1(config-if)# ip address 21.1.6.7 255.255.255.0
Router1(config-if)# exit
```

Removing an EtherChannel

The following example shows how to remove all GE interfaces and delete a Gigabit EtherChannel between two routers:

```
Router1(config)# no interface port-channel 1
GigabitEthernet4/1 taken out of port-channel1
GigabitEthernet5/2 taken out of port-channel1
GigabitEthernet4/2 taken out of port-channel1

Router2(config)# no interface port-channel 1
GigabitEthernet3/1 taken out of port-channel1
GigabitEthernet1/2 taken out of port-channel1
GigabitEthernet3/2 taken out of port-channel1
```

Configuring a POS Channel

The following is a sample configuration of a POS channel between two adjacent routers in which three Packet-over-SONET interfaces on each router are configured in the link bundle.

```
Router1# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(config)# interface pos-channel 1
Router1(config-if)# ip address 41.1.0.1 255.255.0.0
Router1(config-if)# exit
Router1(config)# interface pos5/0
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
  Manually remove other configs.

Continue? [yes]: yes
POS5/0 added as member-1 to POS-channel1
POS5/0, cleared IP address and loopback mode

Router1(config)# interface pos5/1
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
```

```
  Manually remove other configs.

Continue? [yes]: yes
POS5/1 added as member-2 to port-channel1
POS5/1, cleared IP address and loopback mode

Router1(config)# interface pos2/3
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
  Manually remove other configs.

Continue? [yes]: yes
POS2/3 added as member-3 to port-channel1
POS2/3, cleared IP address and loopback mode

Router1(config-if)# exit


Router2# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router2(config)# interface pos-channel 1
Router2(config-if)# ip address 41.1.0.2 255.255.0.0
Router2(config-if)# exit
Router2(config)# interface pos5/0
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
  Manually remove other configs.

Continue? [yes]: yes
POS5/0 added as member-1 to POS-channel1
POS5/0, cleared IP address and loopback mode

Router2(config)# interface pos5/1
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
  Manually remove other configs.

Continue? [yes]: yes
POS5/1 added as member-2 to port-channel1
POS5/1, cleared IP address and loopback mode

Router2(config)# interface pos5/3
Urbana(config-if)# channel-group 1
Command will clear some config: IP address(es), loopback
  Manually remove other configs.

Continue? [yes]: yes
POS5/3 added as member-3 to port-channel1
POS5/3, cleared IP address and loopback mode
```

The following example shows how to verify POS channel connectivity by pinging each router.

```
Router1# ping 41.1.0.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 41.1.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

Router2# ping 41.1.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 41.1.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
```

Removing a POS Channel

The following example shows how to remove all POS interfaces and delete a POS channel between 2 routers:

```
Router1(config)# no interface pos-channel 1
POS5/0 taken out of Poschannel1
POS2/3 taken out of Poschannel1

Router2(config)# no interface pos-channel 1
POS5/0 taken out of Poschannel1
POS5/3 taken out of Poschannel1
```

Configuring Out-of-Service Support

The following example shows how to configure out-of-service support for an EtherChannel so that the following events occur:

- The link bundle is brought down if a minimum number of 4 member interfaces are not up and active.
- The link bundle comes up as soon as 2 member interfaces are up.

```
Router1# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(config)# interface port-channel 1
Router1(config-if)# channel-group minimum active 2
Router1(config-if)# exit
```

Configuring Bandwidth Propagation

The following example shows how to control the propagation of bandwidth changes and configure a bandwidth threshold on an EtherChannel so that as long as up to 4 member interfaces are up and active, the total amount of bandwidth used by the active members in the link bundle is propagated to upper-layer protocols at each bandwidth changes.

Note that this example assumes that there are seven member interfaces and that 2 or more active member interfaces are required for the EtherChannel to be up, as shown in the example for Configuring Out-of-Service Support.

```
Router1# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(config)# interface port-channel 1
Router1(config-if)# channel-group bandwidth control-propagation
Router1(config-if)# channel-group bandwidth threshold 4
Router1(config-if)# exit
```

For the EtherChannel in the preceding example, bandwidth changes are propagated to upper-layer protocols as long as two, three, four, or five member interfaces are active:

- If 2 member interfaces are up, a total bandwidth amount of 2 Gigabits is propagated.
- If 3 member interfaces are up, a total bandwidth amount of 3 Gigabits is propagated.
- If 4 member interfaces are up, a total bandwidth amount of 4 Gigabits is propagated.
- If 5 member interfaces are up, the total bandwidth amount, or 7 Gigabits, of all member interfaces in the EtherChannel is propagated.

As soon as one member interface more than the configured threshold value becomes active (in this example, 5 interfaces), the total bandwidth propagated to upper-layer protocols is the combined total of all member interfaces in the link bundle (in this example, 7 interfaces or 7 Gigabits).

- If 6 member interfaces are up, bandwidth changes are not propagated.
- If 7 member interfaces are up, bandwidth changes are not propagated.

Command Reference

This section documents new commands. All other commands used with this feature are documented in the Cisco IOS Release 12.0 command reference publications.

- **channel-group, page 45**
- **hw-module slot linkbundle-tcam-scalability, page 50**
- **interface port-channel, page 51**
- **interface pos-channel, page 53**
- **show interfaces port-channel, page 55**
- **show interfaces pos-channel, page 60**

channel-group

To assign a Fast Ethernet or Gigabit Ethernet interface to an EtherChannel or a Packet-over-SONET interface to a POS channel link bundle, use the **channel-group** command in interface configuration mode. To remove an interface from an EtherChannel or POS channel, use the **no** form of this command.

channel-group *channel-number*

no channel-group *channel-number*

Use the **channel-group** command in interface configuration mode for an EtherChannel or Packet-over-SONET channel interface to perform the following tasks:

- Control the propagation of bandwidth changes and configure a bandwidth threshold to use for propagating bandwidth changes.
- Configure the minimum number of active members required for the link bundle to stay up.
- Configure VLAN ID-based load-balancing on the Cisco 12000 series ISE, E4+, or E5 member interfaces of an EtherChannel.

To restore the default (minimum number of active links required or bandwidth propagation) settings for an EtherChannel or POS channel, use the **no** form of the following commands. These **channel-group** commands cannot be used for a Fast Ethernet, Gigabit Ethernet, or Packet-over-SONET member interface.

channel-group minimum active *link-number*

no channel-group minimum active *link-number*

channel-group bandwidth control-propagation

no channel-group bandwidth control-propagation

channel-group bandwidth threshold *threshold-number*

no channel-group bandwidth threshold *threshold-number*

channel-group load-share vlan

no channel-group load-share vlan

Syntax Description

channel-number	Port-channel number of the EtherChannel or pos-channel number of the POS channel to which you add (or from which you remove) the GE or POS interface. Assign the port-channel number using the **interface port-channel** command; assign the pos-channel number using the **interface pos-channel** command. The valid values of *channel-number* are from 1 to 16.
minimum active *link-number*	(Optional) Specifies the minimum number of active member links that must be up in order for the link bundle to stay up. The valid values for *link-number* are from 1 to 8.
bandwidth control-propagation	(Optional) Enables the automatic propagation of bandwidth changes to upper-layer protocols for the bandwidth threshold specified by the **bandwidth threshold** *threshold-number* parameter.

bandwidth threshold *threshold-number*	(Optional) Specifies the maximum number of active member links allowed for the total amount of bandwidth used in the active members of a link bundle to be propagated to upper-layer protocols each time there is a change in bandwidth. The valid values for *threshold-number* are from 1 to 8. When a member interface goes up and the number of active links exceeds the threshold number, the aggregate bandwidth of the active members is not propagated. When the number of active members becomes one more than the threshold value, the aggregate bandwidth of all member interfaces (both active and passive) in the bundle is propagated to upper-layer protocols. Note that the **channel-group bandwidth threshold** *threshold-number* command is valid only after you enter the **channel-group bandwidth control-propagation** command. Also, this value is not valid and a bandwidth change is not propagated if the link bundle is down because the minimum number of active member interfaces configured with the **channel-group minimum active** command are not up.
load-share vlan	(Optional- for port-channel interfaces only) Configures load-balancing in an EtherChannel bundle based on the VLAN ID of transmitted packets, instead o f the source and destination IP address of the packets.

Defaults

No channel group is assigned.

The default number of minimum active links required in an EtherChannel or POS channel is 1.

Bandwidth changes are propagated, by default, to upper-layer protocols.

The default load-balancing in an EtherChannel is to balance outgoing traffic across all member links according to the source and destination IP address of transmitted packets.

Command Modes

Interface configuration mode

Command History

Release	Modification
12.0(23)S	This command was introduced on Cisco 12000 series Internet routers.
12.0(26)S	This command was enhanced to include the **minimum active** *link-number* and **bandwidth control-propagation** parameters.
12.0(32)S	This command was enhanced to include the **load-share vlan** parameter.

Usage Guidelines

Configuring an EtherChannel

Before you assign a FE or GE interface to an EtherChannel, you must first create a port-channel logical interface using the **interface port-channel** command in global configuration mode. After you configure a port-channel interface on the router at one end of an EtherChannel, you use the **channel-group** command to add up to eight Fast Ethernet or Gigabit Ethernet interfaces to the EtherChannel group.

The interfaces you add to the port-channel must be of the same Engine number and media type. For example, a Gigabit EtherChannel can consist only of all Engine 1 GE interfaces or all Engine 2 GE interfaces. The interfaces you add to the port-channel can, however, belong to line cards in different slots.

You must add the same number of FE or GE member interfaces to the port-channel logical interface on the router at each end of an EtherChannel (see the "Configuring an EtherChannel" section on page 39).

If the FE or GE interface already has an IP address assigned, you must disable it before adding the interface to an EtherChannel or POS channel. You are prompted to disable the IP address and other configuration settings after you enter the **channel-group** command. To disable the IP address, type **yes** at the prompt.

Note If you do not enter **yes** at the prompt to disable the IP address assigned to a FE or GE interface, the **channel-group** command is aborted. The MAC address assigned by default to an EtherChannel by Cisco IOS software is the MAC address of the first FE or GE member of the port-channel interface.

To display information about an EtherChannel, use the **show interfaces port-channel** command in privileged EXEC mode.

Configuring a POS Channel

Before you assign a POS interface to a POS channel, you must first create a pos-channel logical interface using the **interface pos-channel** command in global configuration mode. After you configure a pos-channel interface on the router at one end of a POS channel, you use the **channel-group** command to add up to eight POS interfaces to the POS channel group.

The interfaces you add to the pos-channel must be of the same Engine number and media type. For example, a POS channel can consist only of all Engine 0 POS interfaces or all Engine 2 POS interfaces. The interfaces you add to the pos-channel can, however, belong to line cards in different slots.

You must add the same number of POS member interfaces to the pos-channel logical interface on the router at each end of a POS channel (see the "Configuring a POS Channel" section on page 41). If the POS interface already has an IP address assigned, you must disable it before adding the interface to a POS channel. You are prompted to disable the IP address and other configuration settings after you enter the **channel-group** command. To disable the IP address, type **yes** at the prompt.

Note If you do not enter **yes** at the prompt to disable the IP address assigned to a POS interface, the **channel-group** command is aborted.

To view information about a POS channel, use the **show interfaces pos-channel** command in privileged EXEC mode.

Out-of-Service Support

Use the **channel-group minimum active** *link-number* command in interface configuration mode for an EtherChannel or POS channel interface to configure the minimum number of active member links that must be up and active in order for the link bundle to stay up.

For example, you can have an EtherChannel that consists of eight Gigabit Ethernet links. By default (that is, if you do not use the **bandwidth** command to configure the amount of available bandwidth), the EtherChannel uses eight gigabits of bandwidth; one gigabit is reserved for each Gigabit Ethernet member interface. However, to avoid overdriving the channel if the amount of required bandwidth falls below three gigabits, you can use the **channel-group minimum active 3** command to specify that the EtherChannel is brought down if fewer than three member links are active.

Bandwidth Propagation

Use the **channel-group bandwidth control-propagation** command in interface configuration mode for an EtherChannel or POS channel interface (see the "interface port-channel" section on page 51 and the "interface pos-channel" section on page 53) to enable and disable the default propagation of the amount of bandwidth used in a link bundle to upper-layer protocols each time there is a bandwidth change. This command allows you to manually control (turn on and off) the propagation of bandwidth changes for the bandwidth threshold specified by the **channel-group bandwidth threshold** *threshold-number* command.

Note The **channel-group bandwidth threshold** *threshold-number* command is only valid if you have already entered the **channel-group bandwidth control-propagation** command in interface configuration mode for an EtherChannel or POS channel interface.

A bandwidth change in a link bundle occurs when any of the following events occur:

- A new, active member interface is added or a member interface is removed.
- An active member interface goes down or a member interface that is down comes up.

The bandwidth threshold is specified according to the number of active member interfaces in the link bundle. When the required number of active member interfaces is less than or equal to the specified threshold number, the total amount of bandwidth used on active members in the link bundle is propagated to upper-layer protocols at each bandwidth change.

When a member interface goes up and the number of active links exceeds the threshold number, the aggregate bandwidth of the active members is not propagated.

When the number of active members becomes one more than the threshold value, the aggregate bandwidth of all member interfaces (both active and passive) in the bundle is propagated to upper-layer protocols.

In addition, bandwidth changes are not propagated if the link bundle goes down because the number of active member interfaces is less than the configured minimum number of active member links required, as described in the "Out-of-Service Support" section on page 47.

Note The **bandwidth** command is supported on an EtherChannel or POS channel interface, but is not supported on a member interface in a link bundle. The bandwidth on each member interface is the default bandwidth value of the interface. The bandwidth on the link bundle is the combined default bandwidth of all active member links.

The **bandwidth** command is supported on a member interface only after you remove it from the link bundle. The bandwidth of the link bundle is then reduced by the default bandwidth of the interface that you removed.

EtherChannel Load-balancing

To configure load-balancing in the link bundle based on the VLAN ID of transmitted packets, use the **channel-group load-share vlan** command in interface configuration mode for an EtherChannel (port-channel) interface. Outgoing traffic is normally balanced across all links in a bundle based on the source and destination IP address of packets. To switch back to per-destination load-balancing, use the **no channel-group load-share vlan** command.

VLAN ID-based load sharing is recommended in an EtherChannel bundle in the following configurations:

- A customer requires VLAN-specific quality-of-service policies on egress traffic, which cannot be achieved due to hardware limitations.
- For Layer 2 traffic or when AToM features are configured on member interfaces, Layer 3 parameters, such as source and destination IP address, are not supported. Load-balancing based on Layer 2 characteristics is, therefore, recommended.
- LAN ID-based load sharing is supported in link bundles on other platforms or third-party devices deployed at the provider edge.

Examples

The following example adds a Gigabit Ethernet interface to the EtherChannel bundle specified by port-channel 1:

```
Router(config)# interface port-channel 1
Router(config-if)# ip address 22.1.0.1 255.255.255.0
Router(config-if)# end
Router(config)# interface gigabitethernet 1/0
Router(config-if)# channel-group 1
```

The next example shows how to configure the automatic propagation of bandwidth changes in the EtherChannel only when two, three or four Gigabit Ethernet member interfaces are up and active:

```
Router(config)# interface port-channel 1
Router(config-if)# channel-group minimum active 2
Router(config-if)# channel-group bandwidth control-propagation
Router(config-if)# channel-group bandwidth threshold 4
```

This example shows how to configure load-balancing across member links of an EtherChannel based on the VLAN ID of transmitted packets:

```
Router(config)# interface port-channel 2
Router(config-if)# channel-group load-share vlan
```

Related Commands

Command	Description
interface port-channel	Specifies an EtherChannel and enters interface configuration mode.
interface pos-channel	Specifies a POS channel and enters interface configuration mode.
show interfaces port-channel	Displays information about an EtherChannel.
show interfaces pos-channel	Displays information about a POS channel.

hw-module slot linkbundle-tcam-scalability

To maximize the amount of VLAN TCAM allocated to process VLAN traffic on a Fast Ethernet or Gigabit Ethernet line card whose interfaces belong to an EtherChannel link bundle, use the **hw-module slot linkbundle-tcam-scalability** command in global configuration mode. To restore the default VLAN TCAM size, use the **no** form of this command.

hw-module slot *number* **linkbundle-tcam-scalability**

Syntax Description

number	Slot number of a line card.

Defaults

No default behavior or values.

Command Modes

Global configuration

Command History

Release	Modification
12.0(32)S	This command was introduced on Cisco 12000 series ISE line cards.

Usage Guidelines

When you increase the number of VLANs on the member interfaces of an EtherChannel, the performance of VLAN load-balancing and data transmission depends on the percentage of ternary content addressable memory (TCAM) allocated for VLANs on each Fast Ethernet or Gigabit Ethernet line card, whose interfaces belong to the link bundle.The **hw-module slot linkbundle-tcam-scalability** command allows you to recarve Layer 2 TCAM regions so that 1K of TCAM is allocated to process VLAN traffic on each subinterface used in a link bundle.

To display the amount of TCAM allocated for Cisco IOS features on a line card, enter the **show controllers frfab alpha tcam carve** command.

After you enter the **hw-module slot linkbundle-tcam-scalability** command, you must enter the **microcode reload** command to reload the software and microcode on the line card so that the newly configured VLAN TCAM size take effect.

Examples

The following example shows how to maximize the VLAN TCAM allocated to member subinterfaces on the Gigabit Ethernet line card in slot 3:

```
Router(config)# hw-module slot 3 linkbundle-tcam-scalability
Router(config)# microcode reload 3
```

Related Commands

Command	Description
show controllers frfab alpha tcam carve	Displays the amount of TCAM allocated to Cisco IOS features on a line card.

interface port-channel

To specify a port-channel interface to associate with an EtherChannel and enter interface configuration mode, use the **interface port-channel** command in global configuration mode. To delete all interfaces from an EtherChannel, use the **no** form of this command.

interface port-channel *channel-number*

no interface port-channel *channel-number*

Syntax Description

channel-number	Specifies the channel number assigned to an EtherChannel.

Defaults

No default behavior or values.

Command Modes

Global configuration mode

Command History

Release	Modification
12.0(23)S	This command was introduced on Cisco 12000 series Internet routers.

Usage Guidelines

The Cisco 12000 series Link Bundling feature allows you to bundle multiple Fast Ethernet or Gigabit Ethernet point-to-point links into one logical link to provide higher bidirectional bandwidth. You can configure an EtherChannel between the following routers:

- Cisco 12000 series Internet routers
- Cisco 12000 series Internet routers and Cisco 7500 series routers or Cisco 7000 series routers with the 7000 Series Route Switch Processor (RSP7000) and 7000 Series Chassis Interface (RSP7000CI) and a Catalyst 5000 switch.

Using the **interface port-channel** command, you configure the port-channel (logical) interface associated with an EtherChannel link bundle. Using the **channel-group** command, you then add up to eight Fast Ethernet or Gigabit Ethernet interfaces to an EtherChannel group.

You must configure the port-channel (logical) interface on the router at each end of the EtherChannel (see the "Configuring an EtherChannel" section on page 39). You can configure a different port-channel number on each router.

To display information about an EtherChannel, use the **show interfaces port-channel** command in privileged EXEC mode.

To delete the counters for one or all Cisco 12000 series FE or GE interfaces in an EtherChannel link bundle, use the **clear counters** command in privileged EXEC mode.

Note If you do not assign a static MAC address on the port-channel interface, Cisco IOS software automatically assigns a MAC address. If you assign a static MAC address and then later remove it, Cisco IOS software automatically assigns a MAC address.

Examples

The following example creates a port-channel interface for an EtherChannel bundle with a channel group number of 1:

```
router# configure terminal
router(config)# interface port-channel 1
router(config-if)# ip address 22.1.0.1 255.255.0.0
router(config-if)# end
```

Related Commands

Command	Description
channel-group	Assigns a Fast Ethernet or Gigabit Ethernet interface to an EtherChannel or a Packet-over-SONET interface to a POS channel.
show interfaces port-channel	Displays information about an EtherChannel.

interface pos-channel

To specify a pos-channel interface to associate with a POS channel link bundle and enter interface configuration mode, use the **interface pos-channel** command in global configuration mode. To delete all interfaces from a POS channel, use the **no** form of this command.

interface pos-channel *channel-number*

no interface pos-channel *channel-number*

Syntax Description

channel-number	Specifies the channel number assigned to a POS channel.

Defaults

No default behavior or values.

Command Modes

Global configuration mode

Command History

Release	Modification
12.0(23)S	This command was introduced on Cisco 12000 series Internet routers.

Usage Guidelines

The Link Bundling feature allows you to bundle multiple Packet-over-SONET point-to-point links into one logical link to provide higher bidirectional bandwidth. You can configure a POS channel between the following routers:

- Cisco 12000 series Internet routers
- Cisco 12000 series Internet routers and Cisco 7500 series routers or Cisco 7000 series routers with the 7000 Series Route Switch Processor (RSP7000) and 7000 Series Chassis Interface (RSP7000CI) and a Catalyst 5000 switch

Using the **interface pos-channel** command, you configure the pos-channel (logical) interface associated with a POS channel link bundle. Using the **channel-group** command, you then add up to 8 packet over SONET interfaces to a POS channel group.

You must configure the pos-channel (logical) interface on the router at each end of the POS channel (see the "Configuring a POS Channel" section on page 41). You can configure a different pos-channel number on each router.

To display information about a POS channel, use the **show interfaces pos-channel** command in privileged EXEC mode.

To delete the counters for one or all POS interfaces in a POS channel link bundle, use the **clear counters** command in privileged EXEC mode.

Examples

The following example creates a pos-channel interface for a POS channel bundle with a channel group number of 3:

```
router# configure terminal
router(config)# interface pos-channel 3
router(config-if)# ip address 23.1.0.1 255.255.0.0
router(config-if)# end
```

Related Commands

Command	Description
channel-group	Assigns a Fast Ethernet or Gigabit Ethernet interface to an EtherChannel or a Packet-over-SONET interface to a POS channel.
show interfaces pos-channel	Displays information about a POS channel.

show interfaces port-channel

To display information about an EtherChannel, use the **show interfaces port-channel** command in privileged EXEC configuration mode.

show interfaces port-channel *channel-number*

Syntax Description

channel-number	Port channel number associated with an EtherChannel. The valid values are from 1 to 16.

Defaults

No default behavior or values.

Command Modes

Privileged EXEC

Command History

Release	Modification
12.0(23)S	This command was introduced on Cisco 12000 series Internet routers.

Usage Guidelines

Use the **show interfaces port-channel** command to display information about the bundled FE or GE links in an EtherChannel.

Examples

The following example shows sample output for a Cisco 12000 series EtherChannel.

```
Router# show interfaces port-channel 1
Port-channel1 is up, line protocol is up
  Hardware is GEChannel, address is 0050.2ac6.9581 (bia 0000.0000.0000)
  Internet address is 22.1.0.2/16
  MTU 1500 bytes, BW 3000000 Kbit, DLY 10 usec, rely 255/255, load 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
    No. of active members in this channel: 3
        Member 0 : GigabitEthernet3/1 , Full-duplex, 1000Mb/s
        Member 1 : GigabitEthernet3/2 , Full-duplex, 1000Mb/s
        Member 2 : GigabitEthernet1/2 , Full-duplex, 1000Mb/s
    No. of passive members in this channel: 0
  Last input 00:00:01, output 00:00:01, output hang never
  Last clearing of "show interface" counters 3d15h
  Queueing strategy: fifo
  Output queue 0/120, 0 drops; input queue 0/225, 0 drops
  30 second input rate 1425032000 bits/sec, 1038111 packets/sec
  30 second output rate 0 bits/sec, 0 packets/sec
     328903597021 packets input, 56454340092292 bytes, 0 no buffer
     Received 50815 broadcasts, 0 runts, 0 giants, 0 throttles
     528238 input errors, 0 CRC, 0 frame, 528238 overrun, 0 ignored
     0 watchdog, 0 multicast, 0 pause input
     128365 packets output, 9409520 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 babbles, 0 late collision, 0 deferred
```

```
     0 lost carrier, 0 no carrier, 0 pause output
     0 output buffer failures, 0 output buffers swapped out
```

Table 5 lists field descriptions for the **show interfaces port-channel** command.

Table 5 show interfaces port-channel Field Descriptions

Field	Description
Port-channel1 is up, line protocol is up	Indicates if the interface hardware is currently active and can transmit and receive, or if it has been taken down by an administrator.
Hardware is	Hardware type (Fast EtherChannel or Gigabit EtherChannel).
address is	MAC address being used by the interface.
MTU	Maximum transmission unit of the interface.
BW	Bandwidth of the interface in kilobits per second.
DLY	Delay of the interface in microseconds.
rely	Reliability of the interface as a fraction of 255 (255/255 is 100% reliability), calculated as an exponential average over 5 minutes.
load	Load on the interface as a fraction of 255 (255/255 is completely saturated), calculated as an exponential average over 5 minutes. The calculation uses the value from the **bandwidth** interface configuration command.
Encapsulation	Encapsulation method assigned to the interface.
loopback	Indicates if loopbacks are set.
Keepalive	Indicates if keepalives are set.
No. of active members in this channel	Indicates the number of FE or GE interfaces in the bundle that are up (active).
No. of passive members in this channel	Indicates the number of FE or GE interfaces in the bundle that are down (passive).
Last input	Number of hours, minutes, and seconds since the last packet was successfully received by an interface. Useful for knowing when a dead interface failed.
output	Number of hours, minutes, and seconds since the last packet was successfully transmitted by an interface.
output hang	Number of hours, minutes, and seconds (or never) since the interface was last reset because of a transmission that took too long. When the number of hours in any of the “last” fields exceeds 24 hours, the number of days and hours is printed. If that field overflows, asterisks are printed.

Field (continued)	Description
Last clearing	Time at which the counters that measure cumulative statistics (such as number of bytes transmitted and received) shown in this report were last reset to zero. Variables that might affect routing (for example, load and reliability) are not cleared when the counters are cleared. *** indicates the elapsed time is too large to be displayed. 0:00:00 indicates the counters were cleared more than 2^{31}ms (and less then 2^{32}ms) ago.
Queueing strategy	First-in, first-out queuing strategy (other queueing strategies you might see are priority-list, custom-list, and weighted fair).
Output queue, drops input queue, drops	Number of packets dropped in output and input queues. Each number is followed by a slash, the maximum size of the queue, and the number of packets dropped because a queue was full.
n second/minute input rate *n* second/minute output rate	Average number of bits and packets received or transmitted per second in the last *n* seconds or minutes.
packets input	Total number of error-free packets received by the system.
bytes (input)	Total number of bytes, including data and MAC encapsulation, in the error-free packets received by the system.
no buffer	Number of received packets discarded because there was no buffer space in the main system. Compare with ignored count. Broadcast storms on Ethernets and bursts of noise on serial lines are often responsible for no input buffer events.
broadcasts	Total number of broadcast or multicast packets received by the interface.
runts	Number of packets that are discarded because they are smaller than the medium's minimum packet size.
giants	Number of packets that are discarded because they exceed the medium's maximum packet size.
throttles	Number of times the receiver on the port was disabled, possibly due to buffer or processor overload.
input errors	Total number of no buffer, runts, giants, CRCs, frame, overrun, ignored, and abort counts. Other input-related errors can also increment the count, so that this sum might not balance with the other counts.

Field (continued)	Description
CRC	Cyclic redundancy checksum generated by the originating LAN station or far-end device does not match the checksum calculated from the data received. On a LAN, this usually indicates noise or transmission problems on the LAN interface or the LAN bus itself. A high number of CRCs is usually the result of collisions or a station transmitting bad data.
frame	Number of packets received incorrectly having a CRC error and a noninteger number of octets. On a serial line, this is usually the result of noise or other transmission problems.
overrun	Number of times the serial receiver hardware was unable to hand received data to a hardware buffer because the input rate exceeded the receiver's ability to manage the data.
ignored	Number of received packets ignored by the interface because the interface hardware ran low on internal buffers. These buffers are different than the system buffers mentioned previously in the buffer description. Broadcast storms and bursts of noise can cause the ignored count to be incremented.
watchdog	Number of times watchdog receive timer expired. It happens when receiving a packet with length greater than 2048.
multicast	Number of multicast packets received.
packets output	Total number of messages transmitted by the system.
bytes (output)	Total number of bytes, including data and MAC encapsulation, transmitted by the system.
underruns	Number of times that the far-end transmitter has been running faster than the near-end router's receiver can manage.
output errors	Sum of all errors that prevented the final transmission of datagrams out of the interface being examined. Note that this might not balance with the sum of the enumerated output errors, as some datagrams can have more than one error, and others can have errors that do not fall into any of the specifically tabulated categories.

Field (continued)	Description
collisions	Number of messages retransmitted due to an Ethernet collision. This is usually the result of an overextended LAN (Ethernet or transceiver cable too long, more than two repeaters between stations, or too many cascaded multiport transceivers). A packet that collides is counted only once in output packets.
interface resets	Number of times an interface has been completely reset. This can happen if packets queued for transmission were not sent within a certain interval. If the system notices that the carrier detect line of an interface is up, but the line protocol is down, it periodically resets the interface in an effort to restart it. Interface resets can also occur when an unrecoverable interface processor error occurred, or when an interface is looped back or shut down.
babbles	The transmit jabber timer expired.
late collision	Number of late collisions. Late collision happens when a collision occurs after transmitting the preamble.
deferred	Indicates that the chip had to defer while ready to transmit a frame because the carrier was asserted.
lost carrier	Number of times the carrier was lost during transmission.
no carrier	Number of times the carrier was not present during the transmission.
output buffer failures	Number of times that a packet was not output from the output hold queue.
output buffers swapped out	Number of packets stored in main memory when the output queue is full; swapping buffers to main memory prevents packets from being dropped when output is congested. The number is high when traffic is bursty.

Related Commands

Command	Description
interface port-channel	Specifies an EtherChannel and enters interface configuration mode.

show interfaces pos-channel

To display information about a POS channel, use the **show interfaces pos-channel** command in privileged EXEC configuration mode.

show interfaces pos-channel *channel-number*

Syntax Description

channel-number	Port channel number associated with a POS channel. The valid values are from 1 to 16.

Defaults

No default behavior or values.

Command Modes

Privileged EXEC

Command History

Release	Modification
12.0(23)S	This command was introduced on Cisco 12000 series Internet routers.

Usage Guidelines

Use the **show interfaces pos-channel** command to display information about the bundled POS links in a POS channel.

Examples

The following example shows sample output for a Cisco 12000 series POS channel.

```
Router# show interfaces pos-channel 1
Pos-channel1 is up, line protocol is up
  Hardware is POSChannel
  Internet address is 41.1.0.1/16
  MTU 4470 bytes, BW 1244000 Kbit, DLY 100 usec, rely 255/255, load 236/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
    No. of active members in this channel: 2
        Member 0 : POS5/0
        Member 1 : POS2/3
    No. of passive members in this channel: 1
        Member 0 : POS5/1
  Last input 00:00:01, output 00:00:03, output hang never
  Last clearing of "show interface" counters 3d15h
  Queueing strategy: fifo
  Output queue 0/80, 3665649311 drops; input queue 0/150, 0 drops
  30 second input rate 0 bits/sec, 0 packets/sec
  30 second output rate 1168138000 bits/sec, 627497 packets/sec
     192649 packets input, 12073574 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     197631584356 packets output, 46098596464843 bytes, 0 underruns
     0 output errors, 0 appliques, 0 interface resets
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
```

Table 6 lists field descriptions for the **show interfaces pos-channel** command.

Table 6 show interfaces pos-channel Field Descriptions

Field	Description
Port-channel1 is up, line protocol is up	Indicates if the interface hardware is currently active and can transmit and receive, or if it has been taken down by an administrator.
Hardware is	Hardware type (POS channel).
MTU	Maximum transmission unit of the interface.
BW	Bandwidth of the interface in kilobits per second.
DLY	Delay of the interface in microseconds.
rely	Reliability of the interface as a fraction of 255 (255/255 is 100% reliability), calculated as an exponential average over 5 minutes.
load	Load on the interface as a fraction of 255 (255/255 is completely saturated), calculated as an exponential average over 5 minutes. The calculation uses the value from the **bandwidth** interface configuration command.
Encapsulation	Encapsulation method assigned to the interface.
loopback	Indicates if loopbacks are set.
Keepalive	Indicates if keepalives are set.
No. of active members in this channel	Indicates the number of Packet-over-SONET interfaces in the bundle that are up (active).
No. of passive members in this channel	Indicates the number of Packet-over-SONET interfaces in the bundle that are down (passive).
Last input	Number of hours, minutes, and seconds since the last packet was successfully received by an interface. Useful for knowing when a dead interface failed.
output	Number of hours, minutes, and seconds since the last packet was successfully transmitted by an interface.
output hang	Number of hours, minutes, and seconds (or never) since the interface was last reset because of a transmission that took too long. When the number of hours in any of the “last” fields exceeds 24 hours, the number of days and hours is printed. If that field overflows, asterisks are printed.

Field (continued)	Description
Last clearing	Time at which the counters that measure cumulative statistics (such as number of bytes transmitted and received) shown in this report were last reset to zero. Variables that might affect routing (for example, load and reliability) are not cleared when the counters are cleared. *** indicates the elapsed time is too large to be displayed. 0:00:00 indicates the counters were cleared more than 2^{31}ms (and less then 2^{32}ms) ago.
Queueing strategy	First-in, first-out queuing strategy (other queueing strategies you might see are priority-list, custom-list, and weighted fair).
Output queue, drops input queue, drops	Number of packets dropped in output and input queues. Each number is followed by a slash, the maximum size of the queue, and the number of packets dropped because a queue was full.
n second/minute input rate *n* second/minute output rate	Average number of bits and packets received or transmitted per second in the last *n* seconds or minutes.
packets input	Total number of error-free packets received by the system.
bytes (input)	Total number of bytes, including data and MAC encapsulation, in the error-free packets received by the system.
no buffer	Number of received packets discarded because there was no buffer space in the main system. Compare with ignored count. Bursts of noise on serial lines are often responsible for no input buffer events.
broadcasts	Total number of broadcast or multicast packets received by the interface.
runts	Number of packets that are discarded because they are smaller than the medium's minimum packet size.
giants	Number of packets that are discarded because they exceed the medium's maximum packet size.
throttles	Number of times the receiver on the port was disabled, possibly due to buffer or processor overload.
input errors	Total number of no buffer, runts, giants, CRCs, frame, overrun, ignored, and abort counts. Other input-related errors can also increment the count, so that this sum might not balance with the other counts.

Field (continued)	Description
CRC	Cyclic redundancy checksum generated by the originating LAN station or far-end device does not match the checksum calculated from the data received. On a LAN, this usually indicates noise or transmission problems on the LAN interface or the LAN bus itself. On a serial link, CRCs usually indicate noise, gain hits, or other transmission problems on the data link.
frame	Number of packets received incorrectly having a CRC error and a noninteger number of octets. On a serial line, this is usually the result of noise or other transmission problems.
overrun	Number of times the serial receiver hardware was unable to hand received data to a hardware buffer because the input rate exceeded the receiver's ability to manage the data.
ignored	Number of received packets ignored by the interface because the interface hardware ran low on internal buffers. These buffers are different than the system buffers mentioned previously in the buffer description. Broadcast storms and bursts of noise can cause the ignored count to be incremented.
abort	Illegal sequence of ones bit on the interface.
packets output	Total number of messages transmitted by the system.
bytes (output)	Total number of bytes, including data and MAC encapsulation, transmitted by the system.
underruns	Number of times that the far-end transmitter has been running faster than the near-end router's receiver can manage.
output errors	Sum of all errors that prevented the final transmission of datagrams out of the interface being examined. Note that this might not balance with the sum of the enumerated output errors, as some datagrams can have more than one error, and others can have errors that do not fall into any of the specifically tabulated categories.
applique	Indicates an unrecoverable error has occurred on the POS IP applique. The system then invokes an interface reset.

Field (continued)	Description
interface resets	Number of times an interface has been completely reset. This can happen if packets queued for transmission were not sent within a certain interval. If the system notices that the carrier detect line of an interface is up, but the line protocol is down, it periodically resets the interface in an effort to restart it. Interface resets can also occur when an unrecoverable interface processor error occurred, or when an interface is looped back or shut down.
output buffer failures	Number of times that a packet was not output from the output hold queue.
output buffers swapped out	Number of packets stored in main memory when the output queue is full; swapping buffers to main memory prevents packets from being dropped when output is congested. The number is high when traffic is bursty.
carrier transitions	Number of times the carrier detect signal of the interface changed state.

Related Commands

Command	Description
interface pos-channel	Specifies a POS channel and enters interface configuration mode.

Glossary

active member—Member interface of an EtherChannel or POS channel whose link status is up and can pass traffic.

ALPHA—Packet-switching ASIC on Cisco 12000 series IP Service Engine (ISE) line cards.

ASIC—application specific integrated circuit. Circuit designs used by manufacturers to consolidate many chips into a single package, reducing board size and power consumption.

EtherChannel—Developed and copyrighted by Cisco Systems. Logical aggregation of multiple Ethernet interfaces used to form a single higher bandwidth routing or bridging endpoint.

Fast EtherChannel members—Fast Ethernet interfaces (both active and passive) added to an EtherChannel.

Gbps—Gigabits per second.

Gigabit EtherChannel members—Gigabit Ethernet interfaces (both active and passive) added to an EtherChannel.

IOS—Cisco IOS software is an innovative and feature-rich network systems software that gives networks intelligence and agility. It allows the effective deployment of new applications and services that enable our customers's business to generate revenue, reduce costs and improve customer service.

link—In the context of a transmission network, a link is a point-to-point connection between adjacent nodes. There can be more than one link between adjacent nodes.

link bundle—Synonym for EtherChannel or POS channel.

passive member—Member interface of an EtherChannel or POS channel whose link status is down and cannot pass traffic.

point-to-point connection—One of two fundamental connection types. Communication between one receiver and one location.

POP—Point of presence. In an Operations Support System (OSS), a physical location where an interexchange carrier installed equipment to interconnect with a local exchange carrier (LEC).

port-channel—Type of interface in Cisco IOS software used to group Fast Ethernet and Gigabit Ethernet interfaces.

POS—Packet-over-SONET. A technology in which IP packets are mapped into SONET frames with intervening use of an ATM layer.

pos-channel—Type of interface in Cisco IOS software used to group Packet-over-SONET interfaces.

POS channel members—POS interfaces (both active and passive) added to a POS channel.

PSA—Packet-switching ASIC on Cisco 12000 series line cards.