Configuring IEEE 802.3ad Link Bundling and Load Balancing

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This document describes how the IEEE 802.3ad Link Bundling feature leverages the EtherChannel infrastructure within Cisco IOS software to manage the bundling of various links. Also described are two network traffic load balancing features that help minimize network disruption that results when a port is added or deleted from a link bundle.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Configuring IEEE 802.3ad Link Bundling and Load Balancing" section on page 27.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

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Prerequisites for Configuring IEEE 802.3ad Link Bundling and Load Balancing

- Knowledge of how EtherChannels and LACP function in a network
- Knowledge of load balancing to mitigate network traffic disruptions
- Verification that both ends of the LACP link have the same baseline software version

Restrictions for Configuring IEEE 802.3ad Link Bundling and Load Balancing

- Number of links supported per bundle is bound by the platform.
- On the Cisco 7600 series router, the maximum number of links per bundle is 8.
- On the Cisco 10000 series router, the maximum number of links per bundle is 8.
- On the Cisco 10000 series router only, 1-gigabit-per-second (Gbps) ports are supported for Gigabit EtherChannels (GECs).
- All links must operate at the same link speed and in full-duplex mode (Link Aggregation Control Protocol [LACP] does not support half-duplex mode).
- All links must be configured as either EtherChannel links or LACP links.
- Only physical interfaces can form aggregations. Aggregations of VLAN interfaces are not possible nor is an aggregation of aggregations.
- If a router is connected to a switch, the bundle terminates on the switch.
- An EtherChannel will not form if one of the LAN ports is a Switched Port Analyzer (SPAN) destination port.
- All ports in an EtherChannel must use the same EtherChannel protocol.
- LACP enhancements described in the "LACP Enhancements" section on page 5 are available only on the Cisco 10000 series router.
- The LACP Single Fault Direct Load Balance Swapping feature is limited to a single bundled port failure.
- The LACP Single Fault Direct Load Balance Swapping feature cannot be used with the Port Aggregation Protocol (PagP).
- LACP port priority cannot be configured with LACP single fault direct load balance swapping and vice versa.
- The adaptive algorithm does not apply to service control engines (SCEs) when EtherChannel load distribution is used.

Information About Configuring IEEE 802.3ad Link Bundling and Load Balancing

Before you set up IEEE 802.3ad Link Bundling or configure load balancing, you should understand the following concepts:

Gigabit EtherChannel

Gigabit EtherChannel is high-performance Ethernet technology that provides Gbps transmission rates. A Gigabit EtherChannel bundles individual Gigabit Ethernet links into a single logical link that provides the aggregate bandwidth of up to eight physical links. All LAN ports in each EtherChannel must be the same speed and all must be configured as either Layer 2 or Layer 3 LAN ports. Inbound broadcast and multicast packets on one link in an EtherChannel are blocked from returning on any other link in the EtherChannel.

When a link within an EtherChannel fails, traffic previously carried over the failed link switches to the remaining links within that EtherChannel. Also when a failure occurs, a trap is sent that identifies the device, the EtherChannel, and the failed link.

Port Channel and LACP-Enabled Interfaces

Each EtherChannel has a numbered port channel interface that, if not already created, is created automatically when the first physical interface is added to the channel group. The configuration of a port channel interface affects all LAN ports assigned to that port channel interface.

To change the parameters of all ports in an EtherChannel, change the configuration of the port channel interface; for example, if you want to configure Spanning Tree Protocol or configure a Layer 2 EtherChannel as a trunk. Any configuration or attribute changes you make to the port channel interface are propagated to all interfaces within the same channel group as the port channel; that is, configuration changes are propagated to the physical interfaces that are not part of the port channel but are part of the channel group.

The configuration of a LAN port affects only that LAN port.

IEEE 802.3ad Link Bundling

The IEEE 802.3ad Link Bundling feature provides a method for aggregating multiple Ethernet links into a single logical channel based on the IEEE 802.3ad standard. This feature helps improve the cost effectiveness of a device by increasing cumulative bandwidth without necessarily requiring hardware upgrades. In addition, IEEE 802.3ad Link Bundling provides a capability to dynamically provision, manage, and monitor various aggregated links and enables interoperability between various Cisco devices and devices of third-party vendors.

LACP supports the automatic creation of EtherChannels by exchanging LACP packets between LAN ports. LACP packets are exchanged only between ports in passive and active modes. The protocol "learns" the capabilities of LAN port groups dynamically and informs the other LAN ports. After LACP identifies correctly matched Ethernet links, it facilitates grouping the links into an EtherChannel. Then the EtherChannel is added to the spanning tree as a single bridge port.

Both the passive and active modes allow LACP to negotiate between LAN ports to determine if they can form an EtherChannel, based on criteria such as port speed and trunking state. (Layer 2 EtherChannels also use VLAN numbers.) LAN ports can form an EtherChannel when they are in compatible LACP modes, as in the following examples:

- A LAN port in active mode can form an EtherChannel with another LAN port that is in active mode.
- A LAN port in active mode can form an EtherChannel with another LAN port in passive mode.
- A LAN port in passive mode cannot form an EtherChannel with another LAN port that is also in passive mode because neither port will initiate negotiation.

LACP uses the following parameters:

- LACP system priority—You must configure an LACP system priority on each device running LACP. The system priority can be configured automatically or through the CLI. LACP uses the system priority with the device MAC address to form the system ID and also during negotiation with other systems.
- LACP port priority—You must configure an LACP port priority on each port configured to use LACP. The port priority can be configured automatically or through the CLI. LACP uses the port priority to decide which ports should be put in standby mode when there is a hardware limitation that prevents all compatible ports from aggregating. LACP also uses the port priority with the port number to form the port identifier.
- LACP administrative key—LACP automatically configures an administrative key value on each port configured to use LACP. The administrative key defines the ability of a port to aggregate with other ports. A port's ability to aggregate with other ports is determined by the following:
  - Port physical characteristics such as data rate, duplex capability, and point-to-point or shared medium
  - Configuration restrictions that you establish

On ports configured to use LACP, it tries to configure the maximum number of compatible ports in an EtherChannel, up to the maximum allowed by the hardware. In Cisco IOS Release 12.2(31)SB2 on the Cisco 10000 series router, only 4 ports per bundle can be aggregated and the peer must be configured to support LACP. To use the hot standby feature in the event a channel port fails, both ends of the LACP bundle must support the **lacp max-bundle** command.

As a control protocol, LACP uses the Slow Protocol Multicast address of 01-80-C2-00-00-02 to transmit LACP protocol data units (PDUs). Aside from LACP, the Slow Protocol linktype is to be utilized by operations, administration, and maintenance (OAM) packets, too. Subsequently, a subtype field is defined per the IEEE 802.3ad standard [1] (Annex 43B, section 4) differentiating LACP PDUs from OAM PDUs.

Benefits of IEEE 802.3ad Link Bundling

IEEE 802.3ad Link Bundling offers the following benefits:

- Increased network capacity without changing physical connections or upgrading hardware
- Cost savings resulting from use of existing hardware and software for additional functions
- A standard solution that enables interoperability of network devices
- Port redundancy without user intervention when an operational port fails

LACP Enhancements

In Cisco IOS Release 12.2(33)SB on the Cisco 10000 series router, the following LACP enhancements are supported:

- Eight member links per LACP bundle.
- Stateful switchover (SSO), in service software upgrade (ISSU), Cisco nonstop forwarding (NSF), and nonstop routing (NSR) on Gigabit EtherChannel bundles.
- PPPoEoE, PPPoEoQinQ, and PPPoVLAN sessions are not forced to reestablish when a link switchover occurs. During the switchover, the port channel is maintained in the LINK_UP state, and both the active and standby links assume the same configured elements after the switchover.
- Link failover time of 250 milliseconds or less and a maximum link failover time of 2 seconds; port channels remain in the LINK_UP state to eliminate reconvergence by the Spanning-Tree Protocol.
- Shutting down a port channel when the number of active links falls below the minimum threshold. In the port channel interface, a configurable option is provided to bring down the port channel interface when the number of active links falls below the minimum threshold. For the port-channel state to be symmetric on both sides of the channel, the peer must also be running LACP and have the same **lacp min-bundle** command setting.
- The IEEE LAG MIB.

EtherChannel Load Balancing

EtherChannel load balancing can use MAC addresses; IP addresses; Layer 4 port numbers; either source addresses, destination addresses, or both; or ports. The selected mode applies to all EtherChannels configured on the device. EtherChannel load balancing can also use Multiprotocol Label Switching (MPLS) Layer 2 information.

Traffic load across the links in an EtherChannel is balanced by reducing part of the binary pattern, formed from the addresses in the frame, to a numerical value that selects one of the links in the channel. When a port is added to an EtherChannel or an active port fails, the load balance bits are reset and

reassigned for all ports within that EtherChannel and reprogrammed into the ASIC for each port. This reset causes packet loss during the time the reassignment and reprogramming is taking place. The greater the port bandwidth, the greater the packet loss.

LACP Single Fault Direct Load Balance Swapping

LACP supports hot standby ports, which are created when a platform's maximum number of ports that can be aggregated are bundled. On the Cisco 7600 router, eight is the maximum number of ports that can be bundled. A hot standby port is bundled in (swapped into) an aggregation when a previously active port fails.

The LACP Single Fault Direct Load Balance Swapping feature reassigns the load balance bits so that the swapped-in hot standby port is assigned the load balance bits of the failed port, and the load balance bits of the remaining ports in the aggregation remain unchanged. When the swapped-in port is bundled, the stored loadshare of the failed port is assigned to the swapped-in port. The remaining ports in the bundle are not affected.

The LACP Single Fault Direct Load Balance Swapping feature addresses a single bundled port failure. If a second failure occurs before the first failure recovers, the loadshare bits for member links are recomputed.

Following is an overview of the LACP single fault direct load balance swapping process:

1. When a failed (unbundled) port is detected and is the first failure, its loadshare is stored.
2. When a hot-standby port is identified and is bundled in, it takes the loadshare bits of the previously failed port.
3. If the failed port comes back up, it replaces the hot-standby port in the bundle and the loadshare bits are transferred back to original port.

The LACP Single Fault Direct Load Balance Swapping feature is enabled using the CLI command **lacp direct-loadswap** in port-channel interface configuration mode.

Load Distribution in an EtherChannel

Prior to Cisco IOS Release 12.(33)SRC, only a fixed load distribution algorithm was supported. With this fixed algorithm, the loadshare bits are assigned sequentially to each port in the bundle. Consequently, the loadshare bits for existing ports change when a member link joins or leaves the bundle. When these values are programmed in the ASIC, substantial traffic disruption and, in some cases, duplication of traffic can occur.

The Load Distribution in an EtherChannel feature enhances the load distribution mechanism with the adaptive load distribution algorithm. This algorithm uses a port reassignment scheme that enhances EtherChannel availability by limiting the load distribution reassignment to the port that is added or deleted. The new load on existing bundled ports does not conflict with the load programmed on those ports when a port is added or deleted.

This feature can be enabled in either global configuration mode or interface configuration mode. The algorithm is applied at the next hash-distribution instance, which usually occurs when a link fails, is activated, added, or removed, or, shut or noshut is configured.

Because the selected algorithm is not applied until the next hash-distribution instance, the current and configured algorithms could be different. If the algorithms are different, a message is displayed alerting you to take appropriate action. For example:

```
Router(config-if)# port-channel port hash-distribution fixed

This command will take effect upon a member link UP/DOWN/ADDITION/DELETION event.
Please do a shut/no shut to take immediate effect
```

Also, the output of the **show etherchannel** command is enhanced to show the applied algorithm when the channel group number is specified. This output enhancement is not available, though, when the protocol is also specified because only protocol-specific information is included. Following is an example of output showing the applied algorithm:

```
Router# show etherchannel 10 summary

Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      N - not in use, no aggregation
        f - failed to allocate aggregator
<snip>
Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
10     Po10(RU)        LACP      Gi3/7(P)       Gi3/9(P)

! The following line of output is added with support
of the EtherChannel Load Distribution feature. !

Last applied Hash Distribution Algorithm: Fixed
Router#
```

How to Configure IEEE 802.3ad Link Bundling and Load Balancing

Perform the following tasks to configure IEEE 802.3ad Link Bundling:

Enabling LACP

Perform this task to enable LACP.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface port-channel** *channel-number*
4. **channel-group** *channel-group-number* **mode** {**active** | **passive**}
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface port-channel** *channel-number* **Example:** `Router(config)# interface port-channel 10`	Identifies the interface port channel and places the command-line interface (CLI) in interface configuration mode.
Step 4	**channel-group** *channel-group-number* **mode** {**active** | **passive**} **Example:** `Router(config-if)# channel-group 25 mode active`	Configures the interface in a channel group and sets it as active. In active mode, the port will initiate negotiations with other ports by sending LACP packets.
Step 5	**end** **Example:** `Router(config-if)# end`	Returns CLI to privileged EXEC mode.

Configuring a Port Channel

You must manually create a port channel logical interface. Perform this task to configure a port channel.

SUMMARY STEPS

1. **enable**
2. **configure terminal**

3. **interface port-channel** *channel-number*
4. **ip address** *ip_address mask*
5. **end**
6. **show running-config interface port-channel** *group_number*
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface port-channel** *channel-number* **Example:** `Router(config)# interface port-channel 10`	Identifies the interface port channel and places the CLI in interface configuration mode.
Step 4	**ip address** *ip_address mask* **Example:** `Router(config-if)# ip address 172.31.52.10 255.255.255.0`	Assigns an IP address and subnet mask to the EtherChannel.
Step 5	**end** **Example:** `Router(config-if)# end`	Returns the CLI to privileged EXEC mode.
Step 6	**show running-config interface port-channel** *group_number* **Example:** `Router# show running-config interface port-channel 10`	Displays the port channel configuration.
Step 7	**end** **Example:** `Router# end`	Ends the current configuration session.

Examples

This example shows how to verify the configuration:

```
Router# show running-config interface port-channel 10

Building configuration...
Current configuration:
!
interface Port-channel10
 ip address 172.31.52.10 255.255.255.0
 no ip directed-broadcast
end
```

Associating a Channel Group with a Port Channel

Perform this task to associate a channel group with a port channel.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface port-channel** *channel-number*
4. **interface** *type number*
5. **channel-group** *channel-group-number* **mode** {**active** | **passive**}
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface port-channel** *channel-number* **Example:** `Router(config)# interface port-channel 5`	Creates a port channel.
Step 4	**interface** *type number* **Example:** `Router(config)# interface gigabitethernet 7/0/0`	Configures a GigabitEthernet interface and places the CLI in interface configuration mode.

	Command or Action	Purpose
Step 5	**channel-group** *channel-group-number* **mode** {**active** | **passive**} **Example:** `Router(config-if)# channel-group 5 mode active`	Includes the interface as part of the port channel bundle.
Step 6	**end** **Example:** `Router(config-if)# end`	Returns the CLI to privileged EXEC mode.

Setting LACP System Priority

Perform this task to set the LACP system priority. The system ID is the combination of the LACP system priority and the MAC address of a device.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **lacp system-priority** *priority*
4. **end**
5. **show lacp sys-id**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**lacp system-priority** *priority* **Example:** `Router(config)# lacp system-priority 200`	Sets the system priority.
Step 4	**end** **Example:** `Router(config)# end`	Returns the CLI to privileged EXEC mode.

	Command or Action	Purpose
Step 5	**show lacp sys-id** **Example:** `Router# show lacp 200`	Displays the system ID, which is a combination of the system priority and the MAC address of the device.
Step 6	**end** **Example:** `Router# end`	Ends the current configuration session.

Examples

This example shows how to verify the LACP configuration:

```
Router# show lacp 200

200.abcd.abcd.abcd.
```

Adding and Removing Interfaces from a Bundle

Perform this task to add and remove an interface from a link bundle.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **channel-group** *channel-group-number* **mode** {**active** | **passive**}
5. **no channel-group** *channel-group-number* **mode** {**active** | **passive**}
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface gigabitethernet 5/0/0`	Configures a GigabitEthernet interface.

	Command or Action	Purpose
Step 4	**channel-group** *channel-group-number* **mode** {**active** | **passive**} **Example:** `Router(config-if)# channel-group 5 mode active`	Adds a GigabitEthernet interface to a channel group and places the CLI in interface configuration mode.
Step 5	**no channel-group** *channel-group-number* **Example:** `Router(config-if)# no channel-group 5 mode active`	Removes the GigabitEthernet interface from channel group.
Step 6	**end** **Example:** `Router(config-if)# end`	Returns the CLI to privileged EXEC mode.

Setting a Minimum Threshold of Active Links

Perform this task to set a minimum number of active links.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **lacp min-bundle** *min-bundle*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface port-channel 1`	Creates a port-channel virtual interface and places the CLI in interface configuration mode.

	Command or Action	Purpose
Step 4	**lacp min-bundle** *min-bundle* *Example:* `Router(config-if)# lacp min-bundle 5`	Sets the minimum threshold of active links to 5.
Step 5	**end** **Example:** `Router(config-if)# end`	Returns the CLI to privileged EXEC mode.

Monitoring LACP Status

Perform this task to monitor LACP activity in the network.

SUMMARY STEPS

1. **enable**
2. **show lacp** {*number* | **counters** | **internal** | **neighbor** | **sys-id**}
3. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show lacp** {*number* | **counters** | **internal** | **neighbor** | **sys-id**} **Example:** `Router# show lacp internal`	Displays internal device information.
Step 3	**end** **Example:** `Router# end`	Ends the current configuration session.

Troubleshooting Tips

Use the **debug lacp** command to display LACP configuration and activity details.

The following sample output from a **debug lacp all** command shows that a remote device is removing a link and also adding a link.

The following sample output shows a remote device removing a link:

```
Router1# debug lacp all

Link Aggregation Control Protocol all debugging is on

Router1#

*Aug 20 17:21:51.685: LACP :lacp_bugpak: Receive LACP-PDU packet via Gi5/0/0
*Aug 20 17:21:51.685: LACP : packet size: 124
*Aug 20 17:21:51.685: LACP: pdu: subtype: 1, version: 1
*Aug 20 17:21:51.685: LACP: Act: tlv:1, tlv-len:20, key:0x1, p-pri:0x8000, p:0x14,
p-state:0x3C,
s-pri:0xFFFF, s-mac:0011.2026.7300
*Aug 20 17:21:51.685: LACP: Part: tlv:2, tlv-len:20, key:0x5, p-pri:0x8000, p:0x42,
p-state:0x3D,
s-pri:0x8000, s-mac:0014.a93d.4a00
*Aug 20 17:21:51.685: LACP: col-tlv:3, col-tlv-len:16, col-max-d:0x8000
*Aug 20 17:21:51.685: LACP: term-tlv:0 termr-tlv-len:0
*Aug 20 17:21:51.685: LACP: Gi5/0/0 LACP packet received, processing
*Aug 20 17:21:51.685:     lacp_rx Gi5: during state CURRENT, got event 5(recv_lacpdu)
*Aug 20 17:21:59.869: LACP: lacp_p(Gi5/0/0) timer stopped
*Aug 20 17:21:59.869: LACP: lacp_p(Gi5/0/0) expired
*Aug 20 17:21:59.869:     lacp_ptx Gi5: during state SLOW_PERIODIC, got event
3(pt_expired)
*Aug 20 17:21:59.869: @@@ lacp_ptx Gi5: SLOW_PERIODIC -> PERIODIC_TX
*Aug 20 17:21:59.869: LACP: Gi5/0/0 lacp_action_ptx_slow_periodic_exit entered
*Aug 20 17:21:59.869: LACP: lacp_p(Gi5/0/0) timer stopped
*Aug 20 17:22:00.869: LACP: lacp_t(Gi5/0/0) timer stopped
*Aug 20 17:22:00.869: LACP: lacp_t(Gi5/0/0) expired
*Aug 20 17:22:19.089: LACP :lacp_bugpak: Receive LACP-PDU packet via Gi5/0/0
*Aug 20 17:22:19.089: LACP : packet size: 124
*Aug 20 17:22:19.089: LACP: pdu: subtype: 1, version: 1
*Aug 20 17:22:19.089: LACP: Act: tlv:1, tlv-len:20, key:0x1, p-pri:0x8000, p:0x14,
p-state:0x4,
s-pri:0xFFFF, s-mac:0011.2026.7300
*Aug 20 17:22:19.089: LACP: Part: tlv:2, tlv-len:20, key:0x5, p-pri:0x8000, p:0x42,
p-state:0x34,
s-pri:0x8000, s-mac:0014.a93d.4a00
*Aug 20 17:22:19.089: LACP: col-tlv:3, col-tlv-len:16, col-max-d:0x8000
*Aug 20 17:22:19.089: LACP: term-tlv:0 termr-tlv-len:0
*Aug 20 17:22:19.089: LACP: Gi5/0/0 LACP packet received, processing
*Aug 20 17:22:19.089:     lacp_rx Gi5: during state CURRENT, got event 5(recv_lacpdu)
*Aug 20 17:22:19.989: LACP: lacp_t(Gi5/0/0) timer stopped
*Aug 20 17:22:19.989: LACP: lacp_t(Gi5/0/0) expired
*Aug 20 17:22:19.989: LACP: timer lacp_t(Gi5/0/0) started with interval 1000.
*Aug 20 17:22:19.989: LACP: lacp_send_lacpdu: (Gi5/0/0) About to send the 110 LACPDU
*Aug 20 17:22:19.989: LACP :lacp_bugpak: Send LACP-PDU packet via Gi5/0/0
*Aug 20 17:22:19.989: LACP : packet size: 124
*Aug 20 17:22:20.957: LACP: lacp_t(Gi5/0/0) timer stopped
*Aug 20 17:22:20.957: LACP: lacp_t(Gi5/0/0) expired
*Aug 20 17:22:21.205: %LINK-3-UPDOWN: Interface GigabitEthernet5/0/0, changed state to
down
*Aug 20 17:22:21.205: LACP: lacp_hw_off: Gi5/0/0 is going down

*Aug 20 17:22:21.205: LACP: if_down: Gi5/0/0
*Aug 20 17:22:21.205:     lacp_ptx Gi5: during state SLOW_PERIODIC, got event
0(no_periodic)
*Aug 20 17:22:22.089: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-channel5,
changed state to down
*Aug 20 17:22:22.153: %C10K_ALARM-6-INFO: CLEAR CRITICAL GigE 5/0/0 Physical Port Link
Down
*Aug 20 17:22:23.413: LACP: Gi5/0/0 oper-key: 0x0
*Aug 20 17:22:23.413: LACP: lacp_hw_on: Gi5/0/0 is coming up
```

```
*Aug 20 17:22:23.413:     lacp_ptx Gi5: during state NO_PERIODIC, got event 0(no_periodic)
*Aug 20 17:22:23.413: @@@ lacp_ptx Gi5: NO_PERIODIC -> NO_PERIODIC
*Aug 20 17:22:23.413: LACP: Gi5/0/0 lacp_action_ptx_no_periodic entered
*Aug 20 17:22:23.413: LACP: lacp_p(Gi5/0/0) timer stopped
*Aug 20 17:22:24.153: %LINK-3-UPDOWN: Interface GigabitEthernet5/0/0, changed state to up
*Aug 20 17:22:24.153: LACP: lacp_hw_on: Gi5/0/0 is coming up

*Aug 20 17:22:24.153:     lacp_ptx Gi5: during state FAST_PERIODIC, got event
0(no_periodic)
*Aug 20 17:22:24.153: @@@ lacp_ptx Gi5: FAST_PERIODIC -> NO_PERIODIC
*Aug 20 17:22:24.153: LACP: Gi5/0/0 lacp_action_ptx_fast_periodic_exit entered
*Aug 20 17:22:24.153: LACP: lacp_p(Gi5/0/0) timer stopped
*Aug 20 17:22:24.153: LACP:
*Aug 20 17:22:25.021: LACP: lacp_p(Gi5/0/0) timer stopped
*Aug 20 17:22:25.021: LACP: lacp_p(Gi5/0/0) expired
*Aug 20 17:22:25.021:     lacp_ptx Gi5: during state FAST_PERIODIC, got event
3(pt_expired)
*Aug 20 17:22:25.021: @@@ lacp_ptx Gi5: FAST_PERIODIC -> PERIODIC_TX
*Aug 20 17:22:25.021: LACP: Gi5/0/0 lacp_action_ptx_fast_periodic_exit entered
*Aug 20 17:22:25.021: LACP: lacp_p(Gi5/0/0) timer stopped
*Aug 20 17:22:25.917: LACP: lacp_p(Gi5/0/0) timer stopped
*Aug 20 17:22:25.917: LACP: lacp_p(Gi5/0/0) expired
*Aug 20 17:22:25.917:     lacp_ptx Gi5: during state FAST_PERIODIC, got event
3(pt_expired)
*Aug 20 17:22:25.917: @@@ lacp_ptx Gi5: FAST_PERIODIC -> PERIODIC_TX
*Aug 20 17:22:25.917: LACP: Gi5/0/0 lacp_action_ptx_fast_periodic_exit entered
*Aug 20 17:22:25.917: LACP: lacp_p(Gi5/0/0) timer stopped
Router1#
```

The following sample output shows a remote device adding a link:

```
Router1#

*Aug 20 17:23:54.005: LACP: lacp_t(Gi5/0/0) timer stopped
*Aug 20 17:23:54.005: LACP: lacp_t(Gi5/0/0) expired
*Aug 20 17:23:55.789: %C10K_ALARM-6-INFO: ASSERT CRITICAL GigE 5/0/0 Physical Port Link
Down
*Aug 20 17:23:56.497: %C10K_ALARM-6-INFO: CLEAR CRITICAL GigE 5/0/0 Physical Port Link
Down
*Aug 20 17:24:19.085: LACP: lacp_p(Gi5/0/0) timer stopped
*Aug 20 17:24:19.085: LACP: lacp_p(Gi5/0/0) expired
*Aug 20 17:24:19.085:     lacp_ptx Gi5: during state SLOW_PERIODIC, got event
3(pt_expired)
*Aug 20 17:24:19.085: @@@ lacp_ptx Gi5: SLOW_PERIODIC -> PERIODIC_TX
*Aug 20 17:24:19.085: LACP: Gi5/0/0 lacp_action_ptx_slow_periodic_exit entered
*Aug 20 17:24:19.085: LACP: lacp_p(Gi5/0/0) timer stopped
*Aug 20 17:24:19.957: LACP: lacp_t(Gi5/0/0) timer stopped
*Aug 20 17:24:19.957: LACP: lacp_t(Gi5/0/0) expired
*Aug 20 17:24:21.073: LACP :lacp_bugpak: Receive LACP-PDU packet via Gi5/0/0
*Aug 20 17:24:21.073: LACP : packet size: 124
*Aug 20 17:24:21.073: LACP: pdu: subtype: 1, version: 1
*Aug 20 17:24:21.073: LACP: Act: tlv:1, tlv-len:20, key:0x1, p-pri:0x8000, p:0x14,
p-state:0xC,
s-pri:0xFFFF, s-mac:0011.2026.7300
*Aug 20 17:24:21.073: LACP: Part: tlv:2, tlv-len:20, key:0x0, p-pri:0x8000, p:0x42,
p-state:0x75,
s-pri:0x8000, s-mac:0014.a93d.4a00
*Aug 20 17:24:21.073: LACP: col-tlv:3, col-tlv-len:16, col-max-d:0x8000
*Aug 20 17:24:21.073: LACP: term-tlv:0 termr-tlv-len:0
*Aug 20 17:24:21.073: LACP: Gi5/0/0 LACP packet received, processing
*Aug 20 17:24:21.073:     lacp_rx Gi5: during state DEFAULTED, got event 5(recv_lacpdu)
*Aug 20 17:24:21.929: LACP: lacp_t(Gi5/0/0) timer stopped
*Aug 20 17:24:21.929: LACP: lacp_t(Gi5/0/0) expired
```

```
*Aug 20 17:24:21.929: LACP: timer lacp_t(Gi5/0/0) started with interval 1000.
*Aug 20 17:24:21.929: LACP: lacp_send_lacpdu: (Gi5/0/0) About to send the 110 LACPDU
*Aug 20 17:24:21.929: LACP :lacp_bugpak: Send LACP-PDU packet via Gi5/0/0
*Aug 20 17:24:21.929: LACP : packet size: 124
*Aug 20 17:24:22.805: LACP: lacp_t(Gi5/0/0) timer stopped
*Aug 20 17:24:22.805: LACP: lacp_t(Gi5/0/0) expired
*Aug 20 17:24:23.025: LACP: lacp_w(Gi5/0/0) timer stopped
*Aug 20 17:24:23.025: LACP: lacp_w(Gi5/0/0) expired
*Aug 20 17:24:23.025:     lacp_mux Gi5: during state WAITING, got event 4(ready)
*Aug 20 17:24:23.025: @@@ lacp_mux Gi5: WAITING -> ATTACHED
*Aug 20 17:24:23.921: LACP: lacp_t(Gi5/0/0) timer stopped
*Aug 20 17:24:23.921: LACP: lacp_t(Gi5/0/0) expired
*Aug 20 17:24:26.025: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-channel5,
changed state to up
```

Enabling LACP Single Fault Load Balance Swapping

Perform this task to enable LACP single fault load balance swapping in EtherChannels.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **lacp direct-loadswap**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface port-channel 1`	Creates a port-channel virtual interface and places the CLI in interface configuration mode.

	Command or Action	Purpose
Step 4	**lacp direct-loadswap** **Example:** `Router(config-if)# lacp direct-loadswap`	Enables LACP single fault direct load balancing.
Step 5	**end** **Example:** `Router(config-if)# end`	Returns the CLI to privileged EXEC mode.

Selecting an EtherChannel Load Distribution Algorithm

The EtherChannel load distribution algorithm can be selected from either global configuration mode or interface configuration mode.

Global Configuration Mode

Perform this task to select either the adaptive or fixed algorithm from global configuration mode.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **port-channel hash-distribution** {**adaptive** | **fixed**}
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**port-channel hash-distribution** {**adaptive** | **fixed**} **Example:** `Router(config)# port-channel hash-distribution adaptive`	Selects the type of algorithm. **Note** If an algorithm is not specified in interface configuration mode, the global configuration is applied. Otherwise, the algorithm specified in interface configuration mode overrides the algorithm specified in global configuration mode.
Step 4	**end** **Example:** `Router(config)# end`	Returns the CLI to privileged EXEC mode.

Interface Configuration Mode

Perform this task to select either the adaptive or fixed algorithm from interface configuration mode.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **port-channel port hash-distribution** {**adaptive** | **fixed**}
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface port-channel 1`	Creates a port-channel virtual interface and places the CLI in interface configuration mode.

	Command or Action	Purpose
Step 4	**port-channel port hash-distribution** {**adaptive** | **fixed**} **Example:** `Router(config-if)# port-channel port hash-distribution adaptive`	Selects the type of algorithm. **Note** If an algorithm is not specified in interface configuration mode, the global configuration is applied. Otherwise, the algorithm specified in interface configuration mode overrides the algorithm specified in global configuration mode.
Step 5	**end** **Example:** `Router(config-if)# end`	Returns the CLI to privileged EXEC mode.

Configuration Examples for Configuring IEEE 802.3ad Link Bundling and Load Balancing

This section contains the following configuration examples:

- Associating a Channel Group with a Port Channel: Example, page 20
- Adding and Removing Interfaces from a Bundle: Example, page 21
- Monitoring LACP Status: Example, page 24

Associating a Channel Group with a Port Channel: Example

This example shows how to configure channel group number 5 and include it in the channel group.

```
Router1# configure terminal

Enter configuration commands, one per line.  End with CNTL/Z.

Router1(config)# interface port 5
Router1(config-if)#

*Aug 20 17:06:14.417: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-channel5,
changed state to down
*Aug 20 17:06:25.413: %LINK-3-UPDOWN: Interface Port-channel5, changed state to down

Router1(config-if)#
Router1(config-if)# interface gigabitethernet 7/0/0
Router1(config-if)# channel-group 5 mode active
Router1(config-if)#

*Aug 20 17:07:43.713: %LINK-3-UPDOWN: Interface GigabitEthernet7/0/0, changed state to
down
*Aug 20 17:07:44.713: %LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet7/0/0, changed state to down
*Aug 20 17:07:45.093: %C10K_ALARM-6-INFO: ASSERT CRITICAL GigE 7/0/0 Physical Port Link
Down
*Aug 20 17:07:45.093: %C10K_ALARM-6-INFO: CLEAR CRITICAL GigE 7/0/0 Physical Port Link
Down
*Aug 20 17:07:47.093: %LINK-3-UPDOWN: Interface GigabitEthernet7/0/0, changed state to up
*Aug 20 17:07:48.093: %LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet7/0/0, changed state to up
```

```
*Aug 20 17:07:48.957: GigabitEthernet7/0/0 added as member-1 to port-channel5

*Aug 20 17:07:51.957: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-channel5,
changed state to up

Router1(config-if)# end
Router1#

*Aug 20 17:08:00.933: %SYS-5-CONFIG_I: Configured from console by console

Router1# show lacp internal

Flags:  S - Device is requesting Slow LACPDUs
        F - Device is requesting Fast LACPDUs
        A - Device is in Active mode       P - Device is in Passive mode

Channel group 5
                            LACP port     Admin     Oper    Port        Port
Port      Flags   State     Priority      Key       Key     Number      State
Gi7/0/0   SA      bndl      32768         0x5       0x5     0x43        0x3D

Router1# show interface port 5

Port-channel5 is up, line protocol is up
  Hardware is GEChannel, address is 0014.a93d.4aa8 (bia 0000.0000.0000)
  MTU 1500 bytes, BW 1000000 Kbit, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 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: 1
        Member 0 : GigabitEthernet7/0/0 , Full-duplex, 1000Mb/s
  Last input 00:00:05, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Interface Port-channel5 queueing strategy: PXF First-In-First-Out
  Output queue 0/8192, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 watchdog, 0 multicast, 0 pause input
     9 packets output, 924 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
Router1#
```

Adding and Removing Interfaces from a Bundle: Example

The following example shows how to add an interface to a bundle:

```
Router1#
Router1# show lacp internal

Flags:  S - Device is requesting Slow LACPDUs
        F - Device is requesting Fast LACPDUs
        A - Device is in Active mode       P - Device is in Passive mode
```

```
Channel group 5
                           LACP port     Admin     Oper    Port        Port
Port      Flags   State    Priority      Key       Key     Number      State
Gi7/0/0   SA      bndl     32768         0x5       0x5     0x43        0x3D

Router1# configure terminal

Enter configuration commands, one per line.  End with CNTL/Z.

Router1(config)# interface gigabitethernet 5/0/0
Router1(config-if)# channel-group 5 mode active
Router1(config-if)#

*Aug 20 17:10:19.057: %LINK-3-UPDOWN: Interface GigabitEthernet5/0/0, changed state to
down
*Aug 20 17:10:19.469: %C10K_ALARM-6-INFO: ASSERT CRITICAL GigE 5/0/0 Physical Port Link
Down
*Aug 20 17:10:19.473: %C10K_ALARM-6-INFO: CLEAR CRITICAL GigE 5/0/0 Physical Port Link
Down
*Aug 20 17:10:21.473: %LINK-3-UPDOWN: Interface GigabitEthernet5/0/0, changed state to up
*Aug 20 17:10:21.473: GigabitEthernet7/0/0 taken out of port-channel5

*Aug 20 17:10:23.413: GigabitEthernet5/0/0 added as member-1 to port-channel5

*Aug 20 17:10:23.473: %LINK-3-UPDOWN: Interface Port-channel5, changed state to up

Router1(config-if)# end
Router1#

*Aug 20 17:10:27.653: %SYS-5-CONFIG_I: Configured from console by console

*Aug 20 17:11:40.717: GigabitEthernet7/0/0 added as member-2 to port-channel5

Router1# show lacp internal

Flags:  S - Device is requesting Slow LACPDUs
        F - Device is requesting Fast LACPDUs
        A - Device is in Active mode       P - Device is in Passive mode

Channel group 5
                           LACP port     Admin     Oper    Port        Port
Port      Flags   State    Priority      Key       Key     Number      State
Gi7/0/0   SA      bndl     32768         0x5       0x5     0x43        0x3D
Gi5/0/0   SA      bndl     32768         0x5       0x5     0x42        0x3D

Router1#
Router1# show interface port 5

Port-channel5 is up, line protocol is up
  Hardware is GEChannel, address is 0014.a93d.4aa8 (bia 0000.0000.0000)
  MTU 1500 bytes, BW 2000000 Kbit, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 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: 2
        Member 0 : GigabitEthernet5/0/0 , Full-duplex, 1000Mb/s  <---- added to port
channel bundle
        Member 1 : GigabitEthernet7/0/0 , Full-duplex, 1000Mb/s
  Last input 00:00:00, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/150/0/0 (size/max/drops/flushes); Total output drops: 0
  Interface Port-channel5 queueing strategy: PXF First-In-First-Out
  Output queue 0/8192, 0 drops; input queue 0/150, 0 drops
```

```
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 watchdog, 0 multicast, 0 pause input
     104 packets output, 8544 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
Router1#
```

The following example shows how to remove an interface from a bundle:

```
Router1#
Router1# configure terminal

Enter configuration commands, one per line.  End with CNTL/Z.

Router1(config)# interface gigabitethernet 7/0/0
Router1(config-if)# no channel-group 5 mode active
Router1(config-if)#

*Aug 20 17:15:49.433: GigabitEthernet7/0/0 taken out of port-channel5

*Aug 20 17:15:49.557: %C10K_ALARM-6-INFO: ASSERT CRITICAL GigE 5/0/0 Physical Port Link
Down
*Aug 20 17:15:50.161: %C10K_ALARM-6-INFO: CLEAR CRITICAL GigE 5/0/0 Physical Port Link
Down
*Aug 20 17:15:51.433: %LINK-3-UPDOWN: Interface GigabitEthernet7/0/0, changed state to
down
*Aug 20 17:15:52.433: %LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet7/0/0, changed state to down

Router1(config-if)# end
Router1#

*Aug 20 17:15:58.209: %SYS-5-CONFIG_I: Configured from console by console
Router1#
*Aug 20 17:15:59.257: %C10K_ALARM-6-INFO: ASSERT CRITICAL GigE 7/0/0 Physical Port Link
Down
*Aug 20 17:15:59.257: %C10K_ALARM-6-INFO: CLEAR CRITICAL GigE 7/0/0 Physical Port Link
Down

Router1#

*Aug 20 17:16:01.257: %LINK-3-UPDOWN: Interface GigabitEthernet7/0/0, changed state to up
*Aug 20 17:16:02.257: %LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet7/0/0, changed state to up

Router1# show lacp internal

Flags:  S - Device is requesting Slow LACPDUs
        F - Device is requesting Fast LACPDUs
        A - Device is in Active mode       P - Device is in Passive mode

Channel group 5
                            LACP port     Admin     Oper    Port        Port
Port      Flags   State     Priority      Key       Key     Number      State
Gi5/0/0   SA      bndl      32768         0x5       0x5     0x42        0x3D
Router1#
```

Monitoring LACP Status: Example

The following example shows LACP activity that you can monitor by using the **show lacp** command.

```
Router1# show lacp internal

Flags:  S - Device is requesting Slow LACPDUs
        F - Device is requesting Fast LACPDUs
        A - Device is in Active mode       P - Device is in Passive mode

Channel group 5
                            LACP port     Admin     Oper    Port        Port
Port      Flags   State     Priority      Key       Key     Number      State
Gi5/0/0   SA      bndl      32768         0x5       0x5     0x42        0x3D

Router1# show lacp 5 counters

              LACPDUs         Marker      Marker Response    LACPDUs
Port       Sent   Recv     Sent   Recv     Sent   Recv      Pkts Err
---------------------------------------------------------------------
Channel group: 5
Gi5/0/0     21     18       0      0        0      0         0

Router1# show lacp 5 internal

Flags:  S - Device is requesting Slow LACPDUs
        F - Device is requesting Fast LACPDUs
        A - Device is in Active mode       P - Device is in Passive mode

Channel group 5
                            LACP port     Admin     Oper    Port        Port
Port      Flags   State     Priority      Key       Key     Number      State
Gi5/0/0   SA      bndl      32768         0x5       0x5     0x42        0x3D

Router1# show lacp 5 neighbor

Flags:  S - Device is requesting Slow LACPDUs
        F - Device is requesting Fast LACPDUs
        A - Device is in Active mode       P - Device is in Passive mode

Channel group 5 neighbors

Partner's information:

          Partner Partner   LACP Partner  Partner   Partner  Partner     Partner
Port      Flags   State     Port Priority Admin Key Oper Key Port Number Port State
Gi5/0/0   SP      32768     0011.2026.7300  11s     0x1      0x14      0x3C

Router1# show lacp counters

              LACPDUs         Marker      Marker Response    LACPDUs
Port       Sent   Recv     Sent   Recv     Sent   Recv      Pkts Err
---------------------------------------------------------------------
Channel group: 5
Gi5/0/0     23     20       0      0        0      0         0

Router1# show lacp sys-id

32768,0014.a93d.4a00
Router1#
```

Additional References

The following sections provide references related to configuring IEEE 802.3ad link bundling and load balancing.

Related Documents

Related Topic	Document Title
Configuring EtherChannels	"Configuring Layer 3 and Layer 2 EtherChannel" chapter of the *Catalyst 6500 Release 12.2SXF Software Configuration Guide*
LACP commands	*Cisco IOS Carrier Ethernet Command Reference*

Standards

Standard	Title
IEEE 802.3ad-2000	*IEEE 802.3ad-2000 Link Aggregation*

MIBs

MIB	MIBs Link
• 802.3ad MIB	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Feature Information for Configuring IEEE 802.3ad Link Bundling and Load Balancing

Table 1 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Release 12.2(31)SB2 or Cisco IOS Releases 12.2(33)SRB or 12.2(33)SRC or a later release appear in the table.

For information on a feature in this technology that is not documented here, see the Carrier Ethernet Features Roadmap.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 1 Feature Information for Configuring IEEE 802.3ad Link Bundling and Load Balancing

Feature Name	Releases	Feature Information
IEEE 802.3ad Faster Link Switchover Time	12.2(33)SB	The IEEE 802.3ad Faster Link Switchover Time feature provides a link failover time of 250 milliseconds or less and a maximum link failover time of 2 seconds. Also, port channels remain in the LINK_UP state to eliminate reconvergence by the Spanning-Tree Protocol. The following sections provide information about this feature: • LACP Enhancements, page 5 The following commands were introduced or modified: **lacp fast-switchover**.
IEEE 802.3ad Link Bundling	12.2(31)SB2 12.2(33)SRB 12.2(33)SRC	The IEEE 802.3ad Link Bundling feature provides a method for aggregating multiple Ethernet links into a single logical channel based on the IEEE 802.3ad standard. In addition, this feature provides a capability to dynamically provision, manage, and monitor various aggregated links and enables interoperability between various Cisco devices and devices of third-party vendors. In 12.2(31)SB2, this feature was implemented on the Cisco 10000 series router. In 12.2(33)SRB, this feature was implemented on the Cisco 7600 router. In 12.2(33)SRC, the **lacp rate** command was added. The following sections provide information about this feature: • IEEE 802.3ad Link Bundling, page 4 • How to Configure IEEE 802.3ad Link Bundling and Load Balancing, page 7 • Configuration Examples for Configuring IEEE 802.3ad Link Bundling and Load Balancing, page 20 The following commands were introduced or modified: **channel-group (interface)**, **debug lacp**, **lacp max-bundle**, **lacp port-priority**, **lacp rate**, **lacp system-priority**, **show lacp**.
IEEE 802.3ad Maximum Number of Links Increased	12.2(33)SB	The IEEE 802.3ad Maximum Number of Links Increased feature supports 8 member links per LACP bundle, an increase from 4 in previous software releases. The following sections provide information about this feature: • LACP Enhancements, page 5 This feature uses no new or modified commands.

Table 1 Feature Information for Configuring IEEE 802.3ad Link Bundling and Load Balancing

Feature Name	Releases	Feature Information
EtherChannel Load Distribution	12.2(33)SRC	The EtherChannel Load Distribution feature uses a port reassignment scheme that enhances EtherChannel availability by limiting the load distribution reassignment to the port that is added or deleted. The new load on existing bundled ports does not conflict with the load programmed on those ports when a port is added or deleted. The following sections provide information about this feature: • Load Distribution in an EtherChannel, page 6 • Selecting an EtherChannel Load Distribution Algorithm, page 18 The following commands were introduced or modified: **port-channel port hash-distribution**, **show etherchannel**.
EtherChannel Min-Links	12.2(33)SB	The EtherChannel Min-Links feature allows a port channel to be shut down when the number of active links falls below the minimum threshold. Using the **lacp min-bundle** command, you can configure the minimum threshold. The following sections provide information about this feature: • LACP Enhancements, page 5 • Setting a Minimum Threshold of Active Links, page 13 The following commands were introduced or modified: **lacp min-bundle**.
LACP Single Fault Direct Load Balance Swapping	12.2(33)SRC	The LACP Single Fault Direct Load Balance Swapping feature reassigns the load balance bits so that the swapped-in hot standby port is assigned the load balance bits of the failed port, and the load balance bits of the remaining ports in the aggregation remain unchanged. When the swapped-in port is bundled, the loadshare is recalculated and the stored loadshare of the failed port is assigned to the swapped-in port. The remaining ports in the bundle are not affected. The following sections provide information about this feature: • LACP Single Fault Direct Load Balance Swapping, page 6 • Enabling LACP Single Fault Load Balance Swapping, page 17 The following commands were introduced or modified: **lacp direct-loadswap**, **show etherchannel**.

Table 1 Feature Information for Configuring IEEE 802.3ad Link Bundling and Load Balancing

Feature Name	Releases	Feature Information
PPPoX Hitless Failover	12.2(33)SB	The PPPoX Hitless Failover feature allows a port channel to remain in the LINK_UP state during a link switchover. In PPPoEoE, PPPoEoQinQ, and PPPoVLAN sessions, both the active and standby links assume the same configured elements after a switchover; the sessions are not forced to reestablish. The following sections provide information about this feature: • LACP Enhancements, page 5 This feature uses no new or modified commands.
SSO – LACP	12.2(33)SB	The SSO – LACP feature supports stateful switchover (SSO), in service software upgrade (ISSU), Cisco nonstop forwarding (NSF), and nonstop routing (NSR) on Gigabit EtherChannel bundles. The following sections provide information about this feature: • LACP Enhancements, page 5 This feature uses no new or modified commands.