Ethernet Channel Configuration Guide IOS XE Release 3S (Cisco ASR 900 Series)

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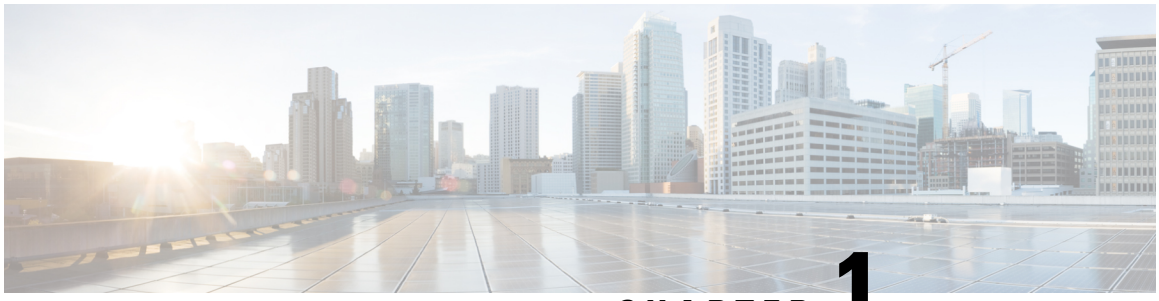


CHAPTER 1

ITU-T G.8032 Ethernet Ring Protection Switching

The ITU-T G.8032 Ethernet Ring Protection Switching feature implements protection switching mechanisms for Ethernet layer ring topologies. This feature uses the G.8032 Ethernet Ring Protection (ERP) protocol, defined in ITU-T G.8032, to provide protection for Ethernet traffic in a ring topology, while ensuring that no loops are within the ring at the Ethernet layer. The loops are prevented by blocking traffic on either a predetermined link or a failed link.

Prerequisites for Configuring ITU-T G.8032 Ethernet Ring Protection Switching

- The Ethernet Flow Points (EFPs) and Trunk Ethernet Flow Points (TEFPs) must be configured.

About ITU-T G.8032 Ethernet Ring Protection Switching

Ring Protection Links

An Ethernet ring consists of multiple Ethernet ring nodes. Each Ethernet ring node is connected to adjacent Ethernet ring nodes using two independent ring links. A ring link prohibits formation of loops that affect the network. The Ethernet ring uses a specific link to protect the entire Ethernet ring. This specific link is called the Ring Protection Link (RPL). A ring link is bound by two adjacent Ethernet ring nodes and a port for a ring link (also known as a ring port). There must be at least two Ethernet ring nodes in an Ethernet ring.

ITU-T G.8032 Ethernet Ring Protection Switching Functionality

The Ethernet ring protection functionality includes the following:

- Loop avoidance

- The use of learning, forwarding, and Filtering Database (FDB) mechanisms

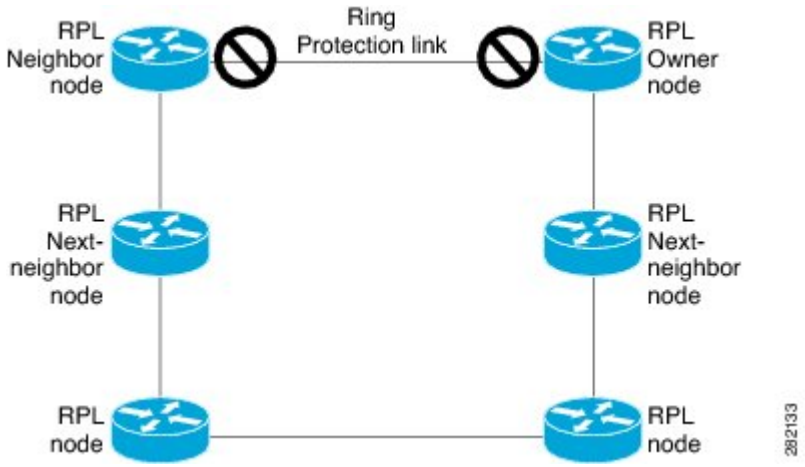
Loop avoidance in an Ethernet ring is achieved by ensuring that, at any time, traffic flows on all but the Ring Protection Link (RPL).

The following is a list of RPL types (or RPL nodes) and their functions:

- RPL owner—Responsible for blocking traffic over the RPL so that no loops are formed in the Ethernet traffic. There can be only one RPL owner in a ring.
- RPL neighbor node—An Ethernet ring node adjacent to the RPL. It is responsible for blocking its end of the RPL under normal conditions. This node type is optional and prevents RPL usage when protected.
- RPL next-neighbor node—Next-neighbor node is an Ethernet ring node adjacent to an RPL owner node or RPL neighbor node. It is mainly used for FDB flush optimization on the ring. This node is also optional.

The following figure illustrates the G.8032 Ethernet ring topology.

Figure 1: G.8032 Ethernet Ring Topology



R-APS Control Messages

Nodes on the ring use control messages called Ring Automatic Protection Switching (R-APS) messages to coordinate the activities of switching the ring protection link (RPL) on and off. Any failure along the ring triggers a R-APS Signal Failure (R-APS SF) message in both directions of the nodes adjacent to the failed link, after the nodes have blocked the port facing the failed link. On obtaining this message, the RPL owner unblocks the RPL port.

Note A single link failure in the ring ensures a loop-free topology.

CFM Protocols and Link Failures

Connectivity Fault Management (CFM) and line status messages are used to detect ring link and node failure. During the recovery phase, when the failed link is restored, the nodes adjacent to the restored link send Ring Automatic Protection Switching (R-APS) No Request (R-APS NR) messages. On obtaining this message, the

ring protection link (RPL) owner blocks the RPL port and sends R-APS NR and R-APS RPL (R-APS NR, RB) messages. These messages cause all other nodes, other than the RPL owner in the ring, to unblock all blocked ports. The Ethernet Ring Protection (ERP) protocol works for both unidirectional failure and multiple link failure scenarios in a ring topology.

Note The G.8032 Ethernet Ring Protection (ERP) protocol uses CFM Continuity Check Messages (CCMs) at an interval of 3.3 milliseconds (ms). At this interval (which is supported only on selected platforms), SONET-like switching time performance and loop-free traffic can be achieved.

G.8032 Ring-Supported Commands and Functionality

A G.8032 ring supports these basic operator administrative commands:

- Force switch (FS)—Allows the operator to forcefully block a particular ring port. Note the following points about FS commands:
  - Effective even if there is an existing SF condition
  - Multiple FS commands for ring are supported
  - May be used to allow immediate maintenance operations
- Manual switch (MS)—Allows the operator to manually block a particular ring port. Note the following points about MS commands:
  - Ineffective in an existing FS or signal failure (SF) condition
  - Overridden by new FS or SF conditions
  - When multiple MS commands are executed more than once on the same device, all MS commands are cancelled.

    When multiple MS commands are executed on different devices in the ring, for the same instance, then the command executed on the second device is rejected.
- Clear—Cancels an existing FS or MS command on the ring port. The Clear command is used at the ring protection link (RPL) owner to clear a nonrevertive mode condition.

A G.8032 ring can support multiple instances. An instance is a logical ring running over a physical ring. Such instances are used for various reasons, such as load-balancing VLANs over a ring. For example, odd-numbered VLANs may go in one direction of the ring, and even-numbered VLANs may go in the other direction. Specific VLANs can be configured under only one instance. They cannot overlap multiple instances. Otherwise, data traffic or Ring Automatic Protection Switching (R-APS) messages may cross logical rings, which is not desirable.

G.8032 ERP Timers

The G.8032 Ethernet Ring Protection (ERP) protocol specifies the use of different timers to avoid race conditions and unnecessary switching operations:

- Delay timers—Used by the Ring Protection Link (RPL) owner to verify that the network has stabilized before blocking the RPL. Note the following points about delay timers.
  - After a signal failure (SF) condition, a Wait-to-Restore (WTR) timer is used to verify that the SF is not intermittent.
  - The WTR timer can be configured by the operator. The default time interval is 5 minutes; the time interval ranges from 1 to 12 minutes.
  - After a force switch (FS) or a manual switch (MS) command is issued, a Wait-to-Block (WTB) timer is used to verify that no background condition exists.

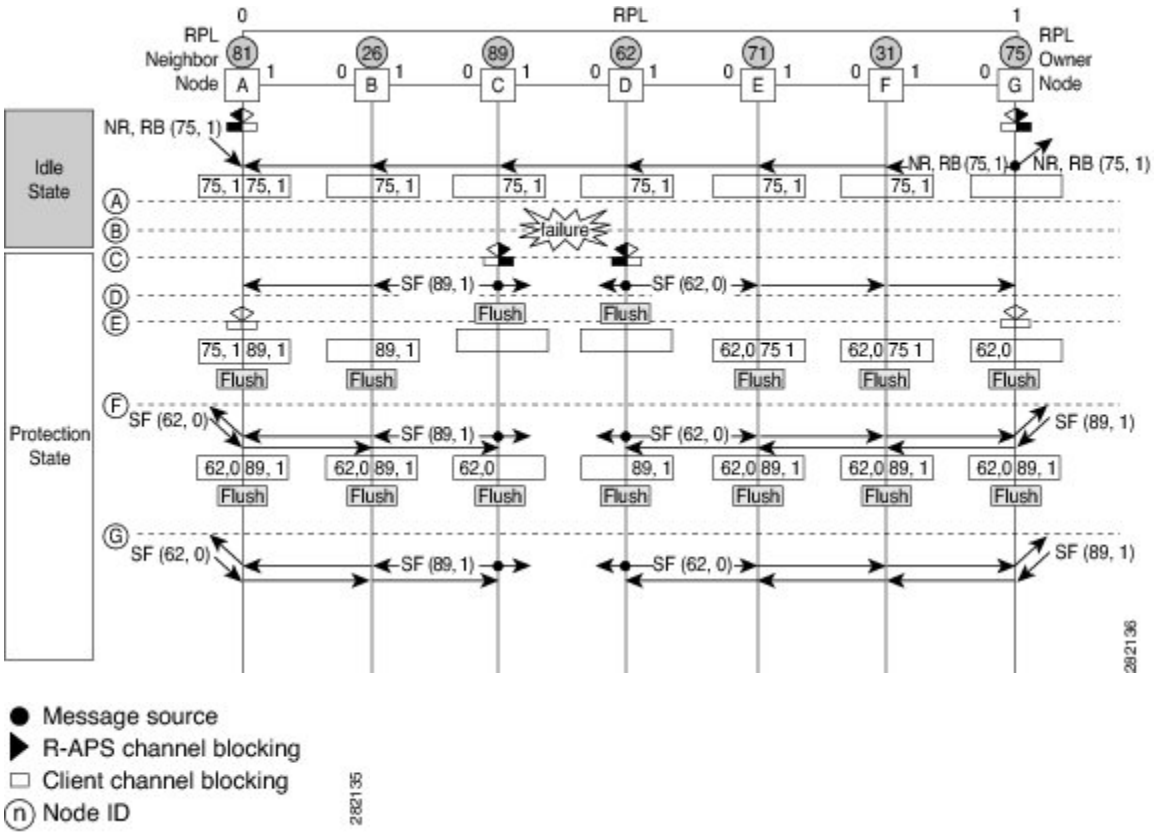
Note The WTB timer interval may be shorter than the WTR timer interval.

- Guard timer—Used by all nodes when changing state; the guard timer blocks latent outdated messages from causing unnecessary state changes. The guard timer can be configured. The default time interval is 500 ms; the time interval ranges from 10 to 2000 ms.
- The recommended Guard Timer for Cisco RSP2 and RSP3 routers is 500 ms.
- Hold-off timers—Used by the underlying Ethernet layer to filter out intermittent link faults. The hold-off timer can be configured. The default time interval is 0 seconds; the time interval ranges from 0 to 10 seconds. Faults are reported to the ring protection mechanism only if this timer expires.

Protection Switching Functionality in a Single Link Failure and Recovery

The following figure illustrates protection switching functionality in a single-link failure.

Figure 2: G.8032 Ethernet Ring Protection Switching in a Single-Link Failure



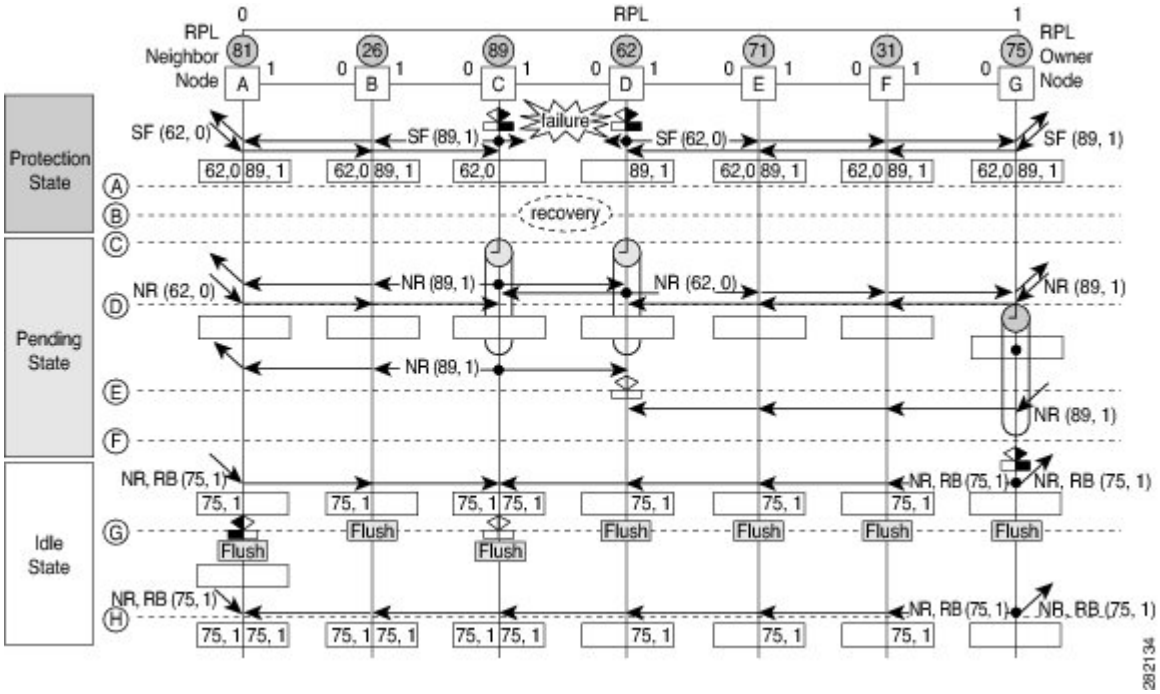
The figure represents an Ethernet ring topology consisting of seven Ethernet ring nodes. The ring protection link (RPL) is the ring link between Ethernet ring nodes A and G. In this topology, both ends of the RPL are blocked. Ethernet ring node G is the RPL owner node, and Ethernet ring node A is the RPL neighbor node.

The following sequence describes the steps followed in the single-link failure:

1. A link operates in the normal condition.
2. A failure occurs.
3. Ethernet ring nodes C and D detect a local signal failure (SF) condition and after the hold-off time interval, block the failed ring port and perform the FDB flush.
4. Ethernet ring nodes C and D start sending Ring Automatic Protection Switching (R-APS) SF messages periodically along with the (node ID and bidirectional path-protected ring (BPR) identifier pair) on both ring ports while the SF condition persists.
5. All Ethernet ring nodes receiving an R-APS SF message perform the FDB flush. When the RPL owner node G and RPL neighbor node A receive an R-APS SF message, the Ethernet ring node unblocks its end of the RPL and performs the FDB flush.
6. All Ethernet ring nodes receiving a second R-APS SF message perform the FDB flush again; the additional FDB flush is because of the node ID and BPR-based configuration.
7. R-APS SF messages are detected on the Ethernet Ring indicating a stable SF condition. Further R-APS SF messages trigger no further action.

The following figure illustrates the steps taken in a revertive operation in a single-link failure.

Figure 3: Single-Link Failure Recovery (Revertive Operation)



The following sequence describes the steps followed in the single-link failure revertive (recovery) operation:

1. A link operates in the stable SF condition.
2. Recovery of link failure occurs.
3. Ethernet ring nodes C and D detect clearing of the SF condition, start the guard timer, and initiate periodic transmission of the R-APS No Request (NR) messages on both ring ports. (The guard timer prevents the reception of R-APS messages.)
4. When the Ethernet ring nodes receive an R-APS NR message, the node ID and BPR identifier pair of a receiving ring port is deleted and the RPL owner node starts the Wait-to-Restore (WTR) timer.
5. When the guard timer expires on Ethernet ring nodes C and D, the nodes may accept the new R-APS messages, if any. Ethernet ring node D receives an R-APS NR message with a higher node ID from Ethernet ring node C, and unblocks its nonfailed ring port.
6. When the WTR timer expires, the RPL owner node blocks its end of the RPL, sends R-APS (NR or route blocked [RB]) message with the (node ID and BPR identifier pair), and performs the FDB flush.
7. When Ethernet ring node C receives an R-APS (NR or RB) message, the node removes the block on its blocked ring ports, and stops sending R-APS NR messages. On the other hand, when the RPL neighbor node A receives an R-APS NR or RB message, the node blocks its end of the RPL. In addition, Ethernet ring nodes A to F perform the FDB flush when receiving an RAPS NR or RB message because of the node ID and BPR-based configuration.

Ethernet Flow Points

An Ethernet flow point (EFP) is a forwarding decision point in the provider edge (PE) router, which gives network designers flexibility to make many Layer 2 flow decisions within the interface. Many EFPs can be configured on a single physical port. (The number varies from one device to another.) EFPs are the logical demarcation points of an Ethernet virtual connection (EVC) on an interface. An EVC that uses two or more user network interfaces (UNIs) requires an EFP on the associated ingress and egress interfaces of every device that the EVC passes through.

EFPs can be configured on any Layer 2 traffic port; however, they are usually configured on UNI ports. The following parameters (matching criteria) can be configured on the EFP:

- Frames of a specific VLAN, a VLAN range, or a list of VLANs (100-150 or 100,103,110)
- Frames with no tags (untagged)
- Frames with identical double-tags (VLAN tags) as specified
- Frames with identical Class of Service (CoS) values

A frame passes each configured match criterion until the correct matching point is found. If a frame does not fit any of the matching criteria, it is dropped. Default criteria can be configured to avoid dropping frames.

You can configure a new type of TEFP called TEFP with encapsulation from bridge domain (BD). All the BDs configured on the switch are part of the VLAN list of the encapsulated TEFP. The TEFP is encapsulated using the **encapsulation dot1q from-bd** command. The feature brings about the following interaction between the Ethernet-EFP and Layer2-bridge domain components:

- If BDs exist in the system and a TEFP with encapsulation from bridge domain is created, then all the BDs get added to the VLAN list of TEFP with encapsulation from bridge domain.
- If TEFP with encapsulation from bridge domain exists in the system and a new BD is created, then the BD is added to the VLAN list of all the TEFP with encapsulation from bridge domain in the system.
- If TEFP with encapsulation from bridge domain exists in the system and a BD gets deleted, and if the deleted BD is not part of an existing TEFP or EFP then it gets deleted from all the TEFP with encapsulation from bridge domain in the system.

The following types of commands can be used in an EFP:

- Rewrite commands—In each EFP, VLAN tag management can be specified with the following actions:
  - Pop—1) pops out a tag; 2) pops out two tags
  - Push— pushes in a tag
  - Translate—1 to 1) changes a tag value; 1 to 2) pops one tag and pushes two tags; 2 to 1) pops two tags and pushes one tag; 2 to 2) changes the value for two tags
- Forwarding commands—Each EFP specifies the forwarding command for the frames that enter the EFP. Only one forwarding command can be configured per EFP. The forwarding options are as follows:
  - Layer 2 point-to-point forwarding to a pseudowire tunnel
  - Multipoint bridge forwarding to a bridge domain entity
  - Local switch-to-switch forwarding between two different interfaces

- Feature commands—In each EFP, the QoS features or parameters can be changed and the ACL can be updated.

Service Instances and Associated EFPs

Configuring a service instance on a Layer 2 port creates a pseudoport or EFP on which you configure EVC features. Each service instance has a unique number per interface, but you can use the same number on different interfaces because service instances on different ports are not related.

An EFP classifies frames from the same physical port to one of the multiple service instances associated with that port, based on user-defined criteria. Each EFP can be associated with different forwarding actions and behavior.

When an EFP is created, the initial state is UP. The state changes to DOWN under the following circumstances:

- The EFP is explicitly shut down by a user.
- The main interface to which the EFP is associated is down or removed.
- If the EFP belongs to a bridge domain, the bridge domain is down.
- The EFP is forced down as an error-prevention measure of certain features.

Use the **service instance ethernet** interface configuration command to create an EFP on a Layer 2 interface and to enter service instance configuration mode. Service instance configuration mode is used to configure all management and control data plane attributes and parameters that apply to the service instance on a per-interface basis. The service instance number is the EFP identifier.

After the device enters service instance configuration mode, you can configure these options:

- default--Sets a command to its defaults
- description--Adds a service instance-specific description
- encapsulation--Configures Ethernet frame match criteria
- exit--Exits from service instance configuration mode
- no--Negates a command or sets its defaults
- shutdown--Takes the service instance out of service

Restrictions for Configuring ITU-T G.8032 Ethernet Ring Protection Switching

- G.8032 is supported only on EFP bridge domains on the physical interface and port-channel interface.

Note G.8032 is supported only on TEFP on the RSP3 Module. Port-channel is not supported on the RSP3 Module.

- G.8032 is supported only on EFP with dot1q, dot1ad, QinQ, or dot1ad-dot1Q encapsulation type.

Note G.8032 is supported only on TEFP with dot1q on the RSP3 Module.

- G.8032 is not supported on cross-connect interface.
- G.8032 does not support more than two ERP instances per ring.
- Link flap occurs while configuring the inclusion or exclusion VLAN list.
- Admin shutdown is highly recommended before making any changes in Connectivity Fault Management (CFM) configuration.
- The **efd notify** command must be used under CFM configuration to notify G.8032 of failures, if any.

How to Configure ITU-T G.8032 Ethernet Ring Protection Switching

Configuring the Ethernet Ring Profile

To configure the Ethernet ring profile, complete the following steps.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ethernet ring g8032 profile** *profile-name*
4. **timer** {**guard** *seconds* | **hold-off** *seconds* | **wtr** *minutes*}
5. **non-revertive**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ethernet ring g8032 profile** *profile-name* **Example:**	Creates the Ethernet ring profile and enters Ethernet ring profile configuration mode.

	Command or Action	Purpose
	`Device(config)# ethernet ring g8032 profile profile1`	
Step 4	**timer** {**guard** *seconds* | **hold-off** *seconds* | **wtr** *minutes*} **Example:** `Device(config-erp-profile)# timer hold-off 5`	Specifies the time interval for the guard, hold-off, and Wait-to-Restore (WTR) timers.
Step 5	**non-revertive** **Example:** `Device(config-erp-profile)# non-revertive`	Specifies a nonrevertive Ethernet ring instance. • By default, Ethernet ring instances are revertive.
Step 6	**end** **Example:** `Device(config-erp-profile)# end`	Returns to user EXEC mode.

Configuring Ethernet CFM MEPs

Configuring Ethernet Connectivity Fault Management (CFM) maintenance endpoints (MEPs) is optional although recommended for fast failure detection and CFM monitoring. When CFM monitoring is configured, note the following points:

- Static remote MEP (RMEP) checking should be enabled.
- The MEPs should be configured to enable Ethernet fault detection.

For information about configuring Ethernet Connectivity Fault Management (CFM) maintenance endpoints (MEPs), see the "Configuring Ethernet Connectivity Fault Management in a Service Provider Network" module of the *Carrier Ethernet Configuration Guide*.

Enabling Ethernet Fault Detection for a Service

To enable Ethernet Fault Detection (EFD) for a service to achieve fast convergence, complete the following steps

Note Link protection is not supported on the RSP3 Module.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ethernet cfm global**
4. **link-protection enable**

5. **link-protection group management vlan** *vlan-id*
6. **link-protection group** *group-number* **pccm vlan** *vlan-id*
7. **ethernet cfm domain***domain-name* **level** *level-id* [**direction outward**]
8. **service** {*ma-name* | *ma-num* | **vlan-id** *vlan-id* | **vpn-id** *vpn-id*} [**port** | **vlan** *vlan-id* [**direction down**]]
9. **continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**]
10. **efd notify g8032**
11. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ethernet cfm global** **Example:** `Device(config)# ethernet cfm global`	Enables Ethernet CFM globally.
Step 4	**link-protection enable** **Example:** `Device(config)# link-protection enable`	Enables link protection globally on the router.
Step 5	**link-protection group management vlan** *vlan-id* **Example:** `Device(config)# link-protection group management vlan 51`	Defines the management VLAN used for link protection.
Step 6	**link-protection group** *group-number* **pccm vlan** *vlan-id* **Example:** `Device(config)# link-protection group 2 pccm vlan 16`	Specifies an ODU-to-ODU continuity check message (P-CCM) VLAN.
Step 7	**ethernet cfm domain***domain-name* **level** *level-id* [**direction outward**] **Example:** `Device(config)# ethernet cfm domain G8032 level 4`	Configures the CFM domain for ODU 1 and enters Ethernet CFM configuration mode.

	Command or Action	Purpose
Step 8	**service** {*ma-name* | *ma-num* | **vlan-id** *vlan-id* | **vpn-id** *vpn-id*} [**port** | **vlan** *vlan-id* [**direction down**]] **Example:** `Device(config-ecfm)# service 8032_service evc 8032-evc vlan 1001 direction down`	Defines a maintenance association for ODU 1 and enters Ethernet CFM service instance configuration mode.
Step 9	**continuity-check** [**interval** *time* | **loss-threshold** *threshold* | **static rmep**] **Example:** `Device(config-ecfm-srv)# continuity-check interval 3.3ms`	Enables the transmission of continuity check messages (CCMs).
Step 10	**efd notify g8032** **Example:** `Device(config-ecfm-srv)# efd notify g8032`	Enables CFM to notify registered protocols when a defect is detected or cleared, which matches the current fault alarm priority.
Step 11	**end** **Example:** `Device(config-ecfm-srv)# end`	Returns to user EXEC mode.

Configuring the Ethernet Protection Ring

To configure the Ethernet Protection Ring (EPR), complete the following steps.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ethernet ring g8032** *ring-name*
4. **port0 interface** *type number*
5. **monitor service instance** *instance-id*
6. **exit**
7. **port1** {**interface***type number* | **none**}
8. **monitor service instance** *instance-id*
9. **exit**
10. **exclusion-list vlan-ids** *vlan-id*
11. **open-ring**
12. **instance** *instance-id*
13. **description** *descriptive-name*
14. **profile** *profile-name*
15. **rpl** {**port0** | **port1**} {**owner** | **neighbor** | **next-neighbor** }
16. **inclusion-list vlan-ids** *vlan-id*

17. **aps-channel**
18. **level** *level-value*
19. **port0 service instance** *instance-id*
20. **port1 service instance** {*instance-id* | **none** }
21. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ethernet ring g8032** *ring-name* **Example:** `Device(config)# ethernet ring g8032 ring1`	Specifies the Ethernet ring and enters Ethernet ring port configuration mode.
Step 4	**port0 interface** *type number* **Example:** `Device(config-erp-ring)# port0 interface gigabitethernet 0/1/0`	Connects port0 of the local node of the interface to the Ethernet ring and enters Ethernet ring protection mode.
Step 5	**monitor service instance** *instance-id* **Example:** `Device(config-erp-ring-port)# monitor service instance 1`	Assigns the Ethernet service instance to monitor the ring port (port0) and detect ring failures.
Step 6	**exit** **Example:** `Device(config-erp-ring-port)# exit`	Exits Ethernet ring port configuration mode.
Step 7	**port1** {**interface***type* *number*	**none**} **Example:** `Device(config-erp-ring)# port1 interface gigabitethernet 0/1/1`	Connects port1 of the local node of the interface to the Ethernet ring and enters Ethernet ring protection mode.
Step 8	**monitor service instance** *instance-id* **Example:**	Assigns the Ethernet service instance to monitor the ring port (port1) and detect ring failures.

	Command or Action	Purpose
	`Device(config-erp-ring-port)# monitor service instance 2`	• The interface (to which port1 is attached) must be a subinterface of the main interface.
Step 9	**exit** **Example:** `Device(config-erp-ring-port)# exit`	Exits Ethernet ring port configuration mode.
Step 10	**exclusion-list vlan-ids** *vlan-id* **Example:** `Device(config-erp-ring)# exclusion-list vlan-ids 2`	Specifies VLANs that are unprotected by the Ethernet ring protection mechanism.
Step 11	**open-ring** **Example:** `Device(config-erp-ring)# open-ring`	Specifies the Ethernet ring as an open ring.
Step 12	**instance** *instance-id* **Example:** `Device(config-erp-ring)# instance 1`	Configures the Ethernet ring instance and enters Ethernet ring instance configuration mode.
Step 13	**description** *descriptive-name* **Example:** `Device(config-erp-inst)# description cisco_customer_instance`	Specifies a descriptive name for the Ethernet ring instance.
Step 14	**profile** *profile-name* **Example:** `Device(config-erp-inst)# profile profile1`	Specifies the profile associated with the Ethernet ring instance.
Step 15	**rpl** {**port0** | **port1**} {**owner** | **neighbor** | **next-neighbor** } **Example:** `Device(config-erp-inst)# rpl port0 neighbor`	Specifies the Ethernet ring port on the local node as the RPL owner, neighbor, or next neighbor.
Step 16	**inclusion-list vlan-ids** *vlan-id* **Example:** `Device(config-erp-inst)# inclusion-list vlan-ids 11`	Specifies VLANs that are protected by the Ethernet ring protection mechanism. **Note** VLANs should be within or equal to VLAN configured in the interface.

	Command or Action	Purpose
Step 17	**aps-channel** **Example:** `Device(config-erp-inst)# aps-channel`	Enters Ethernet ring instance aps-channel configuration mode.
Step 18	**level** *level-value* **Example:** `Device(config-erp-inst-aps)# level 5`	Specifies the Automatic Protection Switching (APS) message level for the node on the Ethernet ring. • All nodes in the Ethernet ring must be configured with the same level.
Step 19	**port0 service instance** *instance-id* **Example:** `Device(config-erp-inst-aps)# port0 service instance 100`	Associates APS channel information with port0.
Step 20	**port1 service instance** {*instance-id* **| none** } **Example:** `Device(config-erp-inst-aps)# port1 service instance 100`	Associates APS channel information with port1.
Step 21	**end** **Example:** `Device(config-erp-inst-aps)# end`	Returns to user EXEC mode.

Configuring Topology Change Notification Propagation

To configure topology change notification (TCN) propagation, complete the following steps.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ethernet tcn-propagation G8032 to {REP | G8032}**
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ethernet tcn-propagation G8032 to {REP | G8032}** **Example:** `Device(config)# ethernet tcn-propagation G8032 to G8032`	Allows topology change notification (TCN) propagation from a source protocol to a destination protocol. • Source and destination protocols vary by platform and release.
Step 4	**end** **Example:** `Device(config)# end`	Returns to user EXEC mode.

Configuring a Service Instance

To configure a service instance, complete the following steps.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **service instance** *instance-id* **ethernet** [*evc-id*]
5. **encapsulation dot1q** *vlan-id* [**native**]
6. **bridge-domain** *bridge-id* [**split-horizon** [**group** *group-id*]]
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:**	Specifies the interface type and number.

	Command or Action	Purpose
	`Device(config)# interface gigabitethernet 0/1/0`	
Step 4	**service instance** *instance-id* **ethernet** [*evc-id*] **Example:** `Device(config-if)# service instance 101 ethernet`	Creates a service instance (an instance of an EVC) on an interface and enters service instance configuration mode.
Step 5	**encapsulation dot1q** *vlan-id* [**native**] **Example:** `Device(config-if-srv)# encapsulation dot1q 13`	Defines the matching criteria to be used in order to map ingress dot1q frames on an interface to the appropriate service instance.
Step 6	**bridge-domain** *bridge-id* [**split-horizon** [**group** *group-id*]] **Example:** `Device(config-if-srv)# bridge-domain 12`	Binds the service instance to a bridge domain instance.
Step 7	**end** **Example:** `Device(config-if-srv)# end`	Exits service instance configuration mode.

Verifying the Ethernet Ring Protection (ERP) Switching Configuration

To verify the ERP switching configuration, use one or more of the following commands in any order.

Note Follow these rules while adding or deleting VLANs from the inclusion list:

- While adding VLAN into the inclusion list, it has to be first added on the interface and then in the G.8032 inclusion list.
- While removing VLAN from the inclusion list, it has to be removed from the G.8032 inclusion list and then from the interface.

Addition or Deletion of VLANs in exclusion list is not supported.

SUMMARY STEPS

1. **enable**
2. **show ethernet ring g8032 status** [*ring-name*] [**instance** [*instance-id*]]
3. **show ethernet ring g8032 brief** [*ring-name*] [**instance** [*instance-id*]]
4. **show ethernet ring g8032 summary**
5. **show ethernet ring g8032 statistics** [*ring-name*] [**instance** [*instance-id*]]
6. **show ethernet ring g8032 profile** [*profile-name*]

7. **show ethernet ring g8032 port status interface** [*type number*]
8. **show ethernet ring g8032 configuration** [*ring-name*] **instance** [*instance-id*]
9. **show ethernet ring g8032 trace** {**ctrl** [*ring-name* **instance** *instance-id*] | **sm**}
10. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show ethernet ring g8032 status** [*ring-name*] [**instance** [*instance-id*]] **Example:** `Device# show ethernet ring g8032 status RingA instance 1`	Displays a status summary for the ERP instance.
Step 3	**show ethernet ring g8032 brief** [*ring-name*] [**instance** [*instance-id*]] **Example:** `Device# show ethernet ring g8032 brief`	Displays a brief description of the functional state of the ERP instance.
Step 4	**show ethernet ring g8032 summary** **Example:** `Device# show ethernet ring g8032 summary`	Displays a summary of the number of ERP instances in each state of the ERP switching process.
Step 5	**show ethernet ring g8032 statistics** [*ring-name*] [**instance** [*instance-id*]] **Example:** `Device# show ethernet ring g8032 statistics RingA instance 1`	Displays the number of events and Ring Automatic Protection Switching (R-APS) messages received for an ERP instance.
Step 6	**show ethernet ring g8032 profile** [*profile-name*] **Example:** `Device# show ethernet ring g8032 profile gold`	Displays the settings for one or more ERP profiles.
Step 7	**show ethernet ring g8032 port status interface** [*type number*] **Example:** `Device# show ethernet ring g8032 port status interface gigabitethernet 0/0/1`	Displays Ethernet ring port status information for the interface.

	Command or Action	Purpose
Step 8	**show ethernet ring g8032 configuration** [*ring-name*] **instance** [*instance-id*] **Example:** `Device# show ethernet ring g8032 configuration RingA instance 1`	Displays the details of the ERP instance configuration manager.
Step 9	**show ethernet ring g8032 trace** {**ctrl** [*ring-name* **instance** *instance-id*] | **sm**} **Example:** `Device# show ethernet ring g8032 trace sm`	Displays information about ERP traces.
Step 10	**end** **Example:** `Device# end`	Returns to privileged EXEC mode.

Configuration Examples for ITU-T G.8032 Ethernet Ring Protection Switching

Example: Configuring Ethernet Ring Protection Switching

The following is an example of an Ethernet Ring Protection (ERP) switching configuration:

```
ethernet ring g8032 profile profile_ABC
 timer wtr 1
 timer guard 100
 timer hold-off  1

ethernet ring g8032 major_ring_ABC
 exclusion-list vlan-ids 1000
 port0 interface  GigabitEthernet 0/0/1
  monitor service instance 103
 port1 interface  GigabitEthernet 0/1/0
  monitor service instance 102
 instance 1
  profile profile_ABC
  rpl port0 owner
  inclusion-list vlan-ids 100
  aps-channel
   port0 service instance 100
   port1 service instance 100
  !
interface GigabitEthernet0/1/0
mtu 9216
 no ip address
 negotiation auto
 service instance trunk 1 ethernet
```

```
  encapsulation dot1q 60-61
  rewrite ingress tag pop 1 symmetric
  bridge-domain from-encapsulation

 !
!
```

Example: Enabling Ethernet Fault Detection for a Service

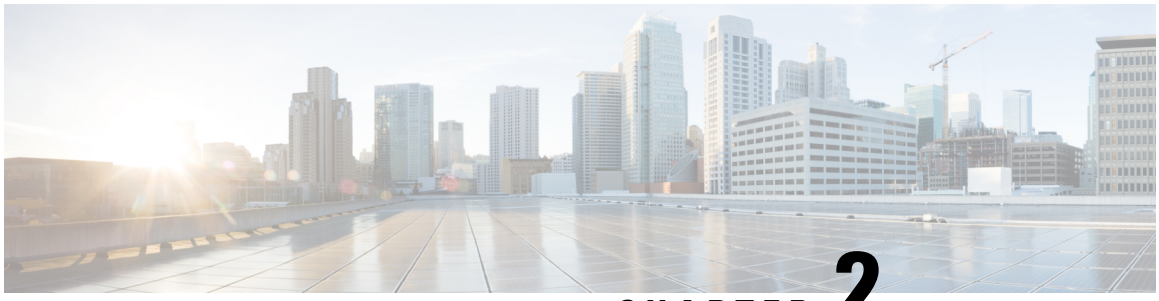
```
ethernet cfm domain G8032 level 4
service 8032_service evc 8032-evc vlan 1001 direction down
  continuity-check
  continuity-check interval 3.3ms
  offload sampling 1000
  efd notify g8032
ethernet ring g8032 profile TEST
timer wtr 1
timer guard 100
ethernet ring g8032 open
open-ring
port0 interface GigabitEthernet0/1/3
  monitor service instance 1001
port1 none
instance 1
  profile TEST
  inclusion-list vlan-ids 2-500,1001
  aps-channel
   port0 service instance 1001
   port1 none
  !
!
instance 2
  profile TEST
  rpl port0 owner
  inclusion-list vlan-ids 1002,1005-2005
  aps-channel
   port0 service instance 1002
   port1 none
  !

interface GigabitEthernet0/1/3
no ip address
load-interval 30
shutdown
negotiation auto
storm-control broadcast level 10.00
storm-control multicast level 10.00
storm-control unicast level 90.00
service instance 1 ethernet
  encapsulation untagged
  l2protocol peer lldp
  bridge-domain 1
!
service instance trunk 10 ethernet
  encapsulation dot1q 2-500,1005-2005
  rewrite ingress tag pop 1 symmetric
  bridge-domain from-encapsulation
!
service instance 1001 ethernet 8032-evc
  encapsulation dot1q 1001
  rewrite ingress tag pop 1 symmetric
```

```
  bridge-domain 1001
  cfm mep domain G8032 mpid 20
!
service instance 1002 ethernet 8032-evc-1
  encapsulation dot1q 1002
  rewrite ingress tag pop 1 symmetric
  bridge-domain 1002
!
End
```

Example: Verifying the Ethernet Ring Protection Configuration

The following is sample output from the **show ethernet ring g8032 configuration** command. Use this command to verify if the configuration entered is valid and to check for any missing configuration parameters.

```
Device# show ethernet ring g8032 configuration

ethernet ring ring0
 Port0: GigabitEthernet0/0/0 (Monitor: GigabitEthernet0/0/0)
 Port1: GigabitEthernet0/0/4 (Monitor: GigabitEthernet0/0/4)
 Exclusion-list VLAN IDs: 4001-4050
 Open-ring: no
 Instance 1
  Description:
  Profile:     opp
  RPL:
  Inclusion-list VLAN IDs: 2,10-500
  APS channel
   Level: 7
   Port0: Service Instance 1
   Port1: Service Instance 1
  State: configuration resolved
```



CHAPTER 2

Configuring IEEE 802.3ad Link Bundling

This document describes how the IEEE 802.3ad Link Bundling feature leverages the EtherChannel infrastructure within Cisco IOS XE software to manage the bundling of Ethernet links. The supported Ethernet link types for link bundling are Gigabit Ethernet and Ten Gigabit Ethernet.

Prerequisites for Configuring IEEE 802.3ad Link Bundling

- Knowledge of how EtherChannels and Link Aggregation Control Protocol (LACP) function in a network
- Verification that both ends of the LACP link have the same baseline software version

Restrictions for Configuring IEEE 802.3ad Link Bundling

- The maximum number of Ethernet links per bundle that can be supported varies by platform. Some platforms support 4 while other platforms support a maximum 8.
- All links must operate at the same link speed and in full-duplex mode (LACP does not support half-duplex mode).
- EVCs must be with configured **untagged** encapsulation along with L2PT peer, to activate the LACP neighbor configuration.
- 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.
- Maximum of four bundled ports per Ethernet port channel are supported.
- The maximum number of bundled ports per Ethernet port channel that can be supported varies by platform. Some platforms support 4, 8, and 14 while other platforms support a maximum of 16.
- Maximum of 64 Ethernet port channels in a chassis are supported.
- For RSP3, a maximum of 48 Ether channel and a maximum of 8 member-link per Ether channel are supported prior to the Cisco IOS XE Gibraltar 16.11.x release. Starting from the Cisco IOS XE Gibraltar 16.11.x release, 16 member-link per port channel is supported. The restrictions for 8 member-link port channel are also applicable for 16 member-link port channel.
- Quality of service (QoS) is supported on individual bundled ports and not on Ethernet port channels.
- Generic Routing Encapsulation (GRE) is not supported.
- Media type should be uniform across 1G and 10G links.
- 16 member links per port channel is supported only for 1G and 10G port-channel bundles.
- For load balancing across 16 member links per port channel, a wide range of addresses (such as Source MAC, Destination MAC, Source IP, Destination IP, and VC) should be used to have the traffic flowing across all the16 member links.
- Maximum of 64 Ethernet port channels in a chassis are supported.
- Quality of service (QoS) is supported on individual bundled ports and not on Ethernet port channels.
- Generic Routing Encapsulation (GRE) is not supported.
- Media type should be uniform across 1G and 10G links.
- 16 member links per port channel is supported only for 1G and 10G port-channel bundles.
- For load balancing across 16 member links per port channel, a wide range of addresses (such as Source MAC, Destination MAC, Source IP, Destination IP, and VC) should be used to have the traffic flowing across all the16 member links.
- LACP neighbor comes up on dot1q tagged EFP. This is a known behavior.
- Effective with Cisco IOS XE Everest 16.6.1, the Port-channel (PoCH) scale is reduced to 24 from 48 for Cisco ASR 900 RSP3 module.

Information About Configuring IEEE 802.3ad Link Bundling

Gigabit EtherChannel

Gigabit EtherChannel (GEC) is high-performance Ethernet technology that provides Gigabit per second (Gb/s) transmission rates. A Gigabit EtherChannel bundles individual Ethernet links (Gigabit Ethernet or Ten Gigabit Ethernet) 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 must be manually created before interfaces can be 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 command-line interface (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. 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.

Note LACP and Port Aggregation Control Protocol (PAgP) are not compatible. Ports configured for PAgP cannot form port channels on ports configured for LACP, and ports configured for LACP cannot form port channels on ports configured for PAgP.

Benefits of IEEE 802.3ad Link Bundling

- Increased network capacity without changing physical connections or upgrading hardware
- Cost savings from the 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

The following LACP enhancements are supported:

- Four 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.
- 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 Link Aggregation Group (LAG) MIB.

LACP for Gigabit Interfaces

The LACP (802.3ad) for Gigabit Interfaces feature bundles individual Ethernet links (Gigabit Ethernet or Ten Gigabit Ethernet) into a single logical link that provides the aggregate bandwidth of up to four physical links.

All LAN ports on a port channel must be the same speed and must all be configured as either Layer 2 or Layer 3 LAN ports. If a segment within a port channel fails, traffic previously carried over the failed link switches to the remaining segments within the port channel. Inbound broadcast and multicast packets on one segment in a port channel are blocked from returning on any other segment of the port channel.

Note The network device may impose its own limits on the number of bundled ports per port channel.

Features Supported on Gigabit EtherChannel Bundles

The table below lists the features that are supported on Gigabit EtherChannel (GEC) bundles.

Table 1: Gigabit EtherChannel Bundle Features

Cisco IOS XE Release	Feature	Bundle Interface
2.5	Access control lists (ACLs) per bundle	Supported
	All Ethernet routing protocols	Supported
	Intelligent Service Gateway (ISG) IP sessions	Not Supported
	Interface statistics	Supported
	IP switching	Supported
	IPv4: unicast and multicast	Supported
	IPv6: unicast without load balancing across member links	Supported
	IPv6: multicast	Supported
	Layer 2 Tunneling Protocol Version 3 (L2TPv3), IPinIP, Any Transport Over Multiprotocol Label Switching (MPLS) (AToM) tunnels	Supported
	Layer 2 Tunneling Protocol Version 2 (L2TPv2)	Not Supported

Cisco IOS XE Release	Feature	Bundle Interface
	MPLS (6PE)	Supported
	Multicast VPN	Not Supported
	VLANs	Supported
2.6	Virtual Private Network (VPN) Routing and Forwarding (VRF)	Supported
3.4	IPv6: unicast and multicast	Supported
3.6	Bidirectional Forwarding Detection (BFD) over GEC	Supported
3.7	Layer 2 Tunneling Protocol Version 2 (L2TPv2)	Supported
	PPPoX (PPPoEoE, PPPoEoQinQ, PPPoVLAN)	Supported
3.7.6	Policy-based routing (PBR) over GEC	Supported
3.11	GEC over L2TPv3	Supported
3.12	MPLS TE (Traffic Engineering) over GEC	Supported

Guidelines for LACP for Gigabit Interfaces Configuration

Port channel interfaces that are configured improperly with LACP are disabled automatically to avoid network loops and other problems. To avoid configuration problems, observe these guidelines and restrictions:

- Every port added to a port channel must be configured identically. No individual differences in configuration are allowed.
- Bundled ports can be configured on different line cards in a chassis.
- Maximum transmission units (MTUs) must be configured on only port channel interfaces; MTUs are propagated to the bundled ports.
- QoS and committed access rate (CAR) are applied at the port level. Access control lists (ACLs) are applied on port channels.
- MAC configuration is allowed only on port channels.
- MPLS IP should be enabled on bundled ports using the **mpls ip** command.
- Unicast Reverse Path Forwarding (uRPF) should be applied on the port channel interface using the **ip verify unicast reverse-path** command in interface configuration mode.
- Cisco Discovery Protocol should be enabled on the port channel interface using the **cdp enable** command in interface configuration mode.

- All LAN ports in a port channel should be enabled. If you shut down a LAN port in a port channel, the shutdown is treated as a link failure and the traffic is transferred to one of the remaining ports in the port channel.
- Create a port channel interface using the **interface port-channel** command in global configuration mode.
- When an Ethernet interface has an IP address assigned, disable that IP address before adding the interface to the port channel. To disable an existing IP address, use the **no ip address** command in interface configuration mode.
- The **hold queue in** command is valid only on port channel interfaces. The **hold queue out** command is valid only on bundled ports.

Five-Tupple Hash Load Balancing

Cisco ASR 900 supports different load balancing hash algorithms with combinations of MAC (L2) or IP (L3) headers on the RSP3 platform to find the hash key. Five-Tupple hash algorithm on RSP3 includes protocol field and L4 port numbers while calculating the hash key. Hash key is calculated based on the following parameters:

- Source IP address
- Destination IP address
- Source port
- Destination port
- Protocol ID (only TCP/UDP is supported for layer 4 protocols)

How to Configure IEEE 802.3ad Link Bundling

Enabling 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:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface port-channel** *channel-number* **Example:** `Device(config)# interface port-channel 10`	Identifies the interface port channel and enters interface configuration mode.
Step 4	**channel-group** *channel-group-number* **mode** {**active** | **passive**} **Example:** `Device(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:** `Device(config-if)# end`	Returns 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. **lacp max-bundle** *max-bundles*
5. **ip address** *ip-address mask*
6. **end**
7. **show running-config interface port-channel** *group-number*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface port-channel** *channel-number* **Example:**	Identifies the interface port channel and enters interface configuration mode.

	Command or Action	Purpose
	`Device(config)# interface port-channel 10`	
Step 4	**lacp max-bundle** *max-bundles* **Example:** `Device(config-if)# lacp max-bundle 3`	Configures three active links on the port channel. The remaining links are in standby mode. Traffic is load-balanced among the active links.
Step 5	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 172.31.52.10 255.255.255.0`	Assigns an IP address and subnet mask to the EtherChannel.
Step 6	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.
Step 7	**show running-config interface port-channel** *group-number* **Example:** `Device# show running-config interface port-channel 10`	Displays the port channel configuration.

Example

This example shows how to verify the configuration:

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

Building configuration...
Current configuration: : 110 bytes
!
interface Port-channel10
ip address 172.31.52.10 255.255.255.0
no negotiation auto
lacp max-bundle 3
end
```

Configuring LACP (802.3ad) for Gigabit Interfaces

Perform this task to create a port channel with two bundled ports. You can configure a maximum of four bundled ports per port channel.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface port-channel** *number*
4. **ip address** *ip-address mask*
5. **interface** *type slot*/*subslot*/ *port*

6. **no ip address**
7. **channel-group** *channel-group-number* **mode** {**active** | **passive**}
8. **exit**
9. **interface** *type slot*/*subslot*/ *port*
10. **no ip address**
11. **channel-group** *channel-group-number* **mode** {**active** | **passive**}
12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface port-channel** *number* **Example:** `Device(config)# interface port-channel 1`	Specifies the port channel interface and enters interface configuration mode. • *number* —Valid range is from 1 to 64.
Step 4	**ip address** *ip-address mask* **Example:** `Device(config-if)# ip address 10.1.1.1 255.255.255.0`	Assigns an IP address and subnet mask to the port channel interface.
Step 5	**interface** *type slot*/*subslot*/ *port* **Example:** `Device(config-if)# interface gigabitethernet 0/0/2`	Specifies the port to bundle.
Step 6	**no ip address** **Example:** `Device(config-if)# no ip address`	Disables the IP address on the port channel interface.
Step 7	**channel-group** *channel-group-number* **mode** {**active** | **passive**} **Example:** `Device(config-if)# channel-group 1 mode active`	Assigns the interface to a port channel group and sets the LACP mode. • *channel-group-number* —Valid range is 1 to 64. • **active** —Places a port into an active negotiating state, in which the port initiates negotiations with other ports by sending LACP packets. • **passive** —Places a port into a passive negotiating state, in which the port responds to LACP packets it receives but does not initiate LACP negotiation. In

	Command or Action	Purpose
		this mode, the channel group attaches the interface to the bundle.
Step 8	**exit** **Example:** `Device(config-if)# exit`	Returns to global configuration mode.
Step 9	**interface** *type slot*/*subslot*/ *port* **Example:** `Device(config)# interface gigabitethernet 0/0/4`	Specifies the next port to bundle and places the CLI in interface configuration mode.
Step 10	**no ip address** **Example:** `Device(config-if)# no ip address`	Disables the IP address on the port channel interface.
Step 11	**channel-group** *channel-group-number* **mode** {**active** | **passive**} **Example:** `Device(config-if)# channel-group 1 mode active`	Assigns the interface to the previously configured port channel group. • *channel-group-number* —Valid range is 1 to 64. • **active** —Places a port into an active negotiating state, in which the port initiates negotiations with other ports by sending LACP packets. • **passive** —Places a port into a passive negotiating state, in which the port responds to LACP packets it receives but does not initiate LACP negotiation. In this mode, the channel-group attaches the interface to the bundle.
Step 12	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

Example

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 1
Device(config-if)# ip address 10.1.1.1 255.255.255.0
Device(config-if)# interface gigabitethernet 0/0/2
Device(config-if)# no ip address
Device(config-if)# channel-group 1 mode active
Device(config-if)# exit
Device(config)# interface gigabitethernet 0/0/4
Device(config-if)# no ip address
Device(config-if)# channel-group 1 mode active
Device(config-if)# end
```

Setting LACP System Priority and Port Priority

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

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **lacp system-priority** *priority*
4. **interface** *slot*/*subslot*/ *port*
5. **lacp port-priority** *priority*
6. **end**
7. **show lacp sys-id**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**lacp system-priority** *priority* **Example:** `Device(config)# lacp system-priority 200`	Sets the system priority.
Step 4	**interface** *slot*/*subslot*/ *port* **Example:** `Device(config)# interface gigabitethernet 0/1/1`	Specifies the bundled port on which to set the LACP port priority and enters interface configuration mode.
Step 5	**lacp port-priority** *priority* **Example:** `Device(config-if)# lacp port-priority 500`	Specifies the priority for the physical interface. • *priority* —Valid range is from 1 to 65535. The higher the number, the lower the priority.
Step 6	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.
Step 7	**show lacp sys-id** **Example:** `Device# show lacp sys-id`	Displays the system ID (a combination of the system priority and the MAC address of the device).

Examples

```
Device> enable
Device# configure terminal
Device(config)# lacp system-priority 200
Device(config)# interface gigabitethernet 0/1/1
Device(config-if)# lacp port-priority 500
Device(config-if)# end
```

This example shows how to verify the LACP configuration:

```
Device# show lacp sys-id
200.abdc.abcd.abcd
```

Adding and Removing Interfaces from a Link Bundle

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type slot/subslot/port*
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:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type slot/subslot/port* **Example:** `Device(config)# interface gigabitethernet 0/0/5`	Configures a Gigabit Ethernet interface.
Step 4	**channel-group** *channel-group-number* **mode** {**active** | **passive**} **Example:** `Device(config-if)# channel-group 5 mode active`	Adds an interface to a channel group and enters interface configuration mode. • In this instance, the interface from Step 3 is added.
Step 5	**no channel-group** *channel-group-number* **mode** {**active** | **passive**}	Removes the Gigabit Ethernet interface from channel group.

	Command or Action	Purpose
	Example: `Device(config-if)# no channel-group 5 mode active`	
Step 6	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

Removing a Channel Group from a Port

Perform this task to remove a Gigabit Ethernet port channel group from a physical port.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no interface port-channel** *number*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**no interface port-channel** *number* **Example:** `Device(config)# no interface port-channel 1`	Removes the specified port channel group from a physical port. • *number*—Valid range is from 1 to 64. **Note** For Cisco ASR 900 RSP3 Module, the valid range of number is from 1 to 48.
Step 4	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode.

Example

```
Device> enable
Device# configure terminal
Device(config)# no interface port-channel 1
Device(config)# end
```

Setting a Minimum Threshold 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:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Device(config)# interface port-channel 1`	Creates a port-channel virtual interface and enters interface configuration mode.
Step 4	**lacp min-bundle** *min-bundle* **Example:** `Device(config-if)# lacp min-bundle 1`	Sets the minimum threshold of active links to 1. **Note** For Cisco ASR 1000 Series Aggregation Services Routers, the minimum number of member links per GEC interface is 1 and the maximum number is 14.
Step 5	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

Monitoring LACP Status

SUMMARY STEPS

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

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show lacp** {*number*	**counters**	**internal**	**neighbor**	**sys-id**} **Example:** `Device# show lacp internal`	Displays internal device information.

Troubleshooting Tips

To verify and isolate a fault, start at the highest level maintenance domain and do the following:

1. Check the device error status.
2. When a error exists, perform a loopback test to confirm the error.
3. Run a traceroute to the destination to isolate the fault.
4. If the fault is identified, correct the fault.
5. If the fault is not identified, go to the next lower maintenance domain and repeat steps 1 through 4 at that maintenance domain level.
6. Repeat the first four steps, as needed, to identify and correct the fault.

Displaying Gigabit EtherChannel Information

To display Gigabit Ethernet port channel information, use the **show interfaces port-channel** command in user EXEC mode or privileged EXEC mode. The following example shows information about port channels configured on ports 0/2 and 0/3. The default MTU is set to 1500 bytes.

```
Device# show interfaces port-channel 1
Port-channel1 is up, line protocol is up
Hardware is GEChannel, address is 0013.19b3.7748 (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 : GigabitEthernet0/0/3 , Full-duplex, 1000Mb/s Member 1 : GigabitEthernet0/1/7 ,
Full-duplex, 1000Mb/s
Last input 00:00:05, output never, output hang never
Last clearing of "show interface" counters 00:04:40
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Interface Port-channel1 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
3 packets output, 180 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
```

The table below describes the significant fields shown in the display.

Table 2: show interfaces port-channel Field Descriptions

Field	Description
Port-channel1 is up, line protocol is up	Indicates the bundle interface is currently active and can transmit and receive or it has been taken down by an administrator.
Hardware is	Hardware type (Gigabit EtherChannel).
address is	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.
reliability	Reliability of the interface as a fraction of 255 (255/255 is 100 percent reliability), calculated as an exponential average over 5 minutes.
tx load rxload	Transmit and receive 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 type assigned to the interface.
loopback	Indicates if loopbacks are set.
keepalive	Indicates if keepalives are set.
ARP type	Address Resolution Protocol (ARP) type on the interface.
ARP Timeout	Number of hours, minutes, and seconds an ARP cache entry stays in the cache.
No. of active members in this channel	Number of bundled ports (members) currently active and part of the port channel group.

Field	Description
Member <*no.*> Gigabit Ethernet: <*no. /no. /no.* >	Number of the bundled port and associated Gigabit Ethernet port channel interface.
Last input	Number of hours, minutes, and seconds since the last packet was successfully received by an interface and processed locally on the Device. Useful for knowing when a dead interface failed. This counter is updated only when packets are process-switched, not when packets are fast-switched.
output	Number of hours, minutes, and seconds since the last packet was successfully transmitted by an interface. This counter is updated only when packets are process-switched, not when packets are fast-switched.
output hang	Number of hours, minutes, and seconds 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.
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 that the elapsed time is too long to be displayed. 0:00:00 indicates that the counters were cleared more than 231 ms and less than 232 ms ago.
Input queue	Number of packets in the input queue and the maximum size of the queue.
Queueing strategy	First-in, first-out queueing strategy (other queueing strategies you might see are priority-list, custom-list, and weighted fair).
Output queue	Number of packets in the output queue and the maximum size of the queue.
5 minute input rate 5 minute output rate	Average number of bits and packets received or transmitted per second in the last 5 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. Broadcast storms on Ethernet lines 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 minimum packet size for the medium.
giants	Number of packets that are discarded because they exceed the maximum packet size for the medium.

Field	Description
input errors	Total number of no buffer, runts, giants, cyclic redundancy checks (CRCs), frame, overrun, ignored, and terminated counts. Other input-related errors can also increment the count, so that this sum might not balance with the other counts.
CRC	CRC 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. A high number of CRCs is usually the result of collisions or a station transmitting bad data. 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 pass received data to a hardware buffer because the input rate exceeded the receiver's capacity for handling 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 the watchdog receive timer expired.
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 Device's receiver can handle.
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.
collisions	Number of messages retransmitted because of an Ethernet collision. 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, the system periodically resets the interface in an effort to restart that interface. Interface resets can also occur when an unrecoverable interface processor error occurred, or when an interface is looped back or shut down.

Field	Description
babbles	The transmit jabber timer expired.
late collision	Number of late collisions. Late collision happens when a collision occurs after transmitting the preamble. The most common cause of late collisions is that your Ethernet cable segments are too long for the speed at which you are transmitting.
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.
PAUSE output	Not supported.
output buffer failures	Number of times that a packet was not output from the output hold queue because of a shortage of shared memory.
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.

Configuring Five-Tupple Hash Load Balancing

Note EoMPLS FAT PW and VPLS FAT PW are not supported because FAT PW uses MAC based hashing algorithm whereas five-tupple hash load balancing feature uses IP Protocol and L4 Port based hashing.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **port-channel load-balance-hash-algo src-dst-mixed-ip-port**
4. **end**

DETAILED STEPS

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

	Command or Action	Purpose
Step 3	**port-channel load-balance-hash-algo src-dst-mixed-ip-port** **Example:** `Device(config)# port-channel load-balance-hash-algo src-dst-mixed-ip-port`	Specifies the source and destination host IP address and TCP/UDP port.
Step 4	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode.

Verification of the five-tupple hash load balancing settings:

```
Device# show etherchannel load-balancing

EtherChannel Load-Balancing Method:
Global LB Method: flow-based
LB Algo type: Source Destination Port, IP addr

  Port-Channel:                       LB Method
```

Configuration Examples for IEEE 802.3ad Link Bundling

Example: Configuring LACP for Gigabit Interfaces

The following example shows how to configure Gigabit Ethernet ports 0/0/2 and 0/0/4 into port channel 1 with LACP parameters.

```
Device> enable
Device# configure terminal
Device(config)# lacp system-priority 65535
Device(config)# interface port-channel 1
Device(config-if)# lacp max-bundle 1
Device(config-if)# ip address 10.1.1.1 255.255.255.0
Device(config-if)# exit
Device(config)# interface gigabitethernet 0/0/2
Device(config-if)# no ip address
Device(config-if)# lacp port-priority 100
Device(config-if)# channel-group 1 mode passive
Device(config-if)# exit
Device(config)# interface gigabitethernet 0/0/4
Device(config-if)# no ip address
Device(config-if)# lacp port-priority 200
Device(config-if)# channel-group 1 mode passive
Device(config-if)# end
```

Example Associating a Channel Group with a Port Channel

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

```
Device1# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Device1(config)# interface port 5
Device1(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
Device1(config-if)#
Device1(config-if)# interface gigabitethernet 0/0/2
Device1(config-if)# channel-group 5 mode active
Device1(config-if)#
*Aug 20 17:07:43.713: %LINK-3-UPDOWN: Interface GigabitEthernet0/0/2, changed state to down
*Aug 20 17:07:44.713: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0/2,
 changed state to down
*Aug 20 17:07:45.093: %C10K_ALARM-6-INFO: ASSERT CRITICAL GigE 0/0/2 Physical Port Link
Down
*Aug 20 17:07:45.093: %C10K_ALARM-6-INFO: CLEAR CRITICAL GigE 0/0/2 Physical Port Link Down

*Aug 20 17:07:47.093: %LINK-3-UPDOWN: Interface GigabitEthernet0/0/2, changed state to up
*Aug 20 17:07:48.093: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0/2,
 changed state to up
*Aug 20 17:07:48.957: GigabitEthernet0/0/2 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
Device1(config-if)# end
Device1#
*Aug 20 17:08:00.933: %SYS-5-CONFIG_I: Configured from console by console
Device1# show etherchannel summary
Flags:  D - down        P/bndl - bundled in port-channel
        I - stand-alone s/susp - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1       Po1(RU)         LACP     Te0/3/0(bndl) Te0/3/1(hot-sby)

RU - L3 port-channel UP State
SU - L2 port-channel UP state
P/bndl -  Bundled
S/susp  - Suspended

Device1# show running-config int po1
Building configuration...

Current configuration : 87 bytes
!
interface Port-channel1
 no ip address
 lacp fast-switchover
 lacp max-bundle 1
end
```

```
Device1# 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
Gi0/0/7   SA      bndl      32768         0x5       0x5     0x43        0x3D
Device1# 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 : GigabitEthernet0/0/2 , 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
```

Example Adding and Removing Interfaces from a Bundle

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

```
Device1# 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
Gi0/0/7   SA      bndl      32768         0x5       0x5     0x43        0x3D
Device1# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Device1(config)# interface gigabitethernet 0/0/5
Device1(config-if)# channel-group 5 mode active
Device1(config-if)#
*Aug 20 17:10:19.057: %LINK-3-UPDOWN: Interface GigabitEthernet0/0/5, changed state to down
*Aug 20 17:10:19.469: %C10K_ALARM-6-INFO: ASSERT CRITICAL GigE 0/0/5 Physical Port Link
Down
*Aug 20 17:10:19.473: %C10K_ALARM-6-INFO: CLEAR CRITICAL GigE 0/0/5 Physical Port Link Down

*Aug 20 17:10:21.473: %LINK-3-UPDOWN: Interface GigabitEthernet0/0/5, changed state to up
*Aug 20 17:10:21.473: GigabitEthernet0/0/7 taken out of port-channel5
*Aug 20 17:10:23.413: GigabitEthernet0/0/5 added as member-1 to port-channel5

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

```
Device1(config-if)# end
Device1#
*Aug 20 17:10:27.653: %SYS-5-CONFIG_I: Configured from console by console
*Aug 20 17:11:40.717: GigabitEthernet0/0/7 added as member-2 to port-channel5

Device1# 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
Gi0/0/7   SA      bndl      32768         0x5       0x5     0x43        0x3D
Gi0/0/7   SA      bndl      32768         0x5       0x5     0x42        0x3D
Device1#
Device1# 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 : GigabitEthernet0/0/5 , Full-duplex, 1000Mb/s  <---- added to port channel
 bundle
        Member 1 : GigabitEthernet0/0/7 , 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
```

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

```
Device1# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Device1(config)# interface gigabitethernet 0/0/7
Device1(config-if)# no channel-group 5 mode active
Device1(config-if)#
*Aug 20 17:15:49.433: GigabitEthernet0/0/7 taken out of port-channel5
*Aug 20 17:15:49.557: %C10K_ALARM-6-INFO: ASSERT CRITICAL GigE 0/0/5 Physical Port Link
Down
*Aug 20 17:15:50.161: %C10K_ALARM-6-INFO: CLEAR CRITICAL GigE 0/0/5 Physical Port Link Down

*Aug 20 17:15:51.433: %LINK-3-UPDOWN: Interface GigabitEthernet0/0/7, changed state to down
*Aug 20 17:15:52.433: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0/7,
 changed state to down
Device1(config-if)# end
Device1#
*Aug 20 17:15:58.209: %SYS-5-CONFIG_I: Configured from console by console
Device1#
*Aug 20 17:15:59.257: %C10K_ALARM-6-INFO: ASSERT CRITICAL GigE 0/0/7 Physical Port Link
```

```
Down
*Aug 20 17:15:59.257: %C10K_ALARM-6-INFO: CLEAR CRITICAL GigE 0/0/7 Physical Port Link Down

Device1#
*Aug 20 17:16:01.257: %LINK-3-UPDOWN: Interface GigabitEthernet0/0/7, changed state to up
*Aug 20 17:16:02.257: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0/7,
 changed state to up
Device1# 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
Gi0/0/5   SA      bndl      32768         0x5       0x5     0x42        0x3D
```

Example Monitoring LACP Status

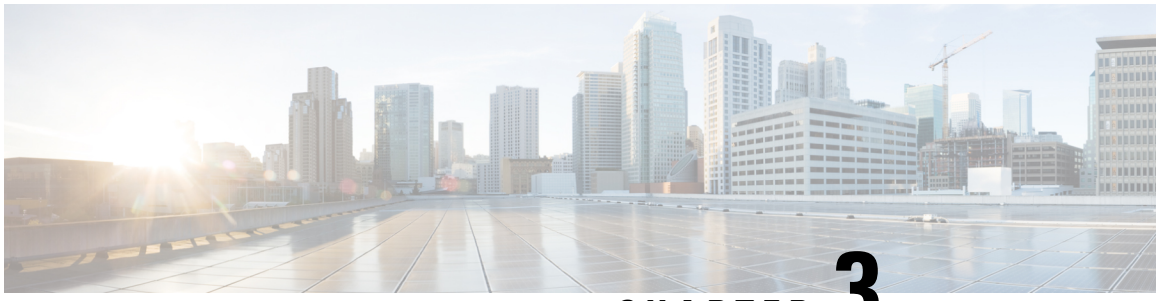
The following example shows LACP activity that you can monitor by using the **show lacp** command.

```
Device1# 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
Gi0/0/5   SA      bndl      32768         0x5       0x5     0x42        0x3D
Device1# show lacp 5 counters
            LACPDUs         Marker      Marker Response    LACPDUs
Port       Sent   Recv     Sent   Recv     Sent   Recv      Pkts Err
---------------------------------------------------------------------
Channel group: 5
Gi0/0/5     21     18       0      0        0      0         0
Device1# 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
Gi0/0/5   SA      bndl      32768         0x5       0x5     0x42        0x3D
Device1# 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
Gi0/0/5   SP      32768     0011.2026.7300  11s    0x1     0x14     0x3C
Device1# show lacp counters
            LACPDUs         Marker      Marker Response    LACPDUs
Port       Sent   Recv     Sent   Recv     Sent   Recv      Pkts Err
---------------------------------------------------------------------
Channel group: 5
Gi0/0/5     23     20       0      0        0      0         0
Device1# show lacp sys-id
32768,0014.a93d.4a00
```

Example: Displaying Port-Channel Interface Information

The following example shows how to display the configuration of port-channel interface 1.

```
Device# show interface port-channel 1
Port-channel1 is up, line protocol is up
Hardware is GEChannel, address is 0013.19b3.7748 (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 : GigabitEthernet0/0/3 , Full-duplex, 1000Mb/s Member 1 : GigabitEthernet0/0/7 ,
Full-duplex, 1000Mb/s
Last input 00:00:05, output never, output hang never
Last clearing of "show interface" counters 00:04:40
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Interface Port-channel1 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
3 packets output, 180 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
```



CHAPTER 3

Multichassis LACP

In Carrier Ethernet networks, various redundancy mechanisms provide resilient interconnection of nodes and networks. The choice of redundancy mechanisms depends on various factors such as transport technology, topology, single node versus entire network multihoming, capability of devices, autonomous system (AS) boundaries or service provider operations model, and service provider preferences.

Carrier Ethernet network high-availability can be achieved by employing both intra- and interchassis redundancy mechanisms. Cisco's Multichassis EtherChannel (MCEC) solution addresses the need for interchassis redundancy mechanisms, where a carrier wants to "dual home" a device to two upstream points of attachment (PoAs) for redundancy. Some carriers either cannot or will not run loop prevention control protocols in their access networks, making an alternative redundancy scheme necessary. MCEC addresses this issue with enhancements to the 802.3ad Link Aggregation Control Protocol (LACP) implementation. These enhancements are provided in the Multichassis LACP (mLACP) feature described in this document.

Prerequisites for mLACP

- The command **lacp max-bundle** must be used on all PoAs in order to operate in PoA control and shared control modes.
  - The maximum number of links configured cannot be less than the total number of interfaces in the link aggregation group (LAG) that is connected to the PoA.
  - Each PoA may be connected to a dual-homed device (DHD) with a different number of links for the LAG (configured with a different number of maximum links).
- Each PoA must be configured using the **lacp min-bundle** command with the desired minimum number of links to maintain the LAG in the active state.
- For DHD control there must be an equal number of links going to each PoA.
- The max-bundle value must equal the number of active links connected locally to the PoA (no local intra-PoA active or standby protection).

- LACP fast switchover must be configured on all devices to speed convergence.

Restrictions for mLACP

- You can enable MC-LAG to bring down mLACP during standby, if the BDI interface is associated with only port channel (part of mLACP). If the BDI interface is associated with more than one interface (1k BDI with no physical interface and logical interface port channel in the systems), then that BDI cannot be brought down when the mLACP goes to standby.
- mLACP does not support Fast Ethernet.
- mLACP does not support half-duplex links.
- mLACP does not support multiple neighbors.
- Converting a port channel to mLACP can cause a service disruption.
- The maximum number of member links per LAG per PoA is restricted by the maximum number of ports per port channel, as limited by the platform.
- System priority on a DHD must be a lesser priority than on PoAs in POA and shared mode.
- MAC Tunneling Protocol (MTP) supports only one member link in a port channel.
- A port-channel or its member links may flap while LACP stabilizes.
- DHD-based control does not function when min-links is not configured.
- DHD-controlled revertive behavior with min-links is not supported.
- Brute-force failover always causes min-link failures.
- Any failure with brute-force failover behaves revertively.

The following restrictions are applicable on the Cisco Aggregation Services Routers 900 Series:

- The lacp max-bundle max-links command must be used on all the PoAs in order to operate in PoA control and shared control modes.
  - The value of the max-links variable must be greater than the total number of interfaces in the LAG, which are connected to the PoA.
  - Each PoA may be connected to the dual-homed device (DHD) with a different number of links for the LAG (and, hence configured with a different value for the max-links value) variable.
- The **lacp min-bundle min-links** command has local scope only. Each PoA must be configured with the required minimum number of links to maintain the LAG in active state.
- mLACP and Pseudo-mLACP (P-mLACP) feature interoperation between the Cisco 7600 Series Routers and the Cisco ASR 903 is not supported when the former is used as one PoA and the Cisco ASR 903 as another PoA in the same redundancy group.
- VPLS over port channel (PoCH) flaps on SSO with LACP rate fast.
- MAC Tunneling Protocol (MTP) is not supported.
- The following commands are not supported:

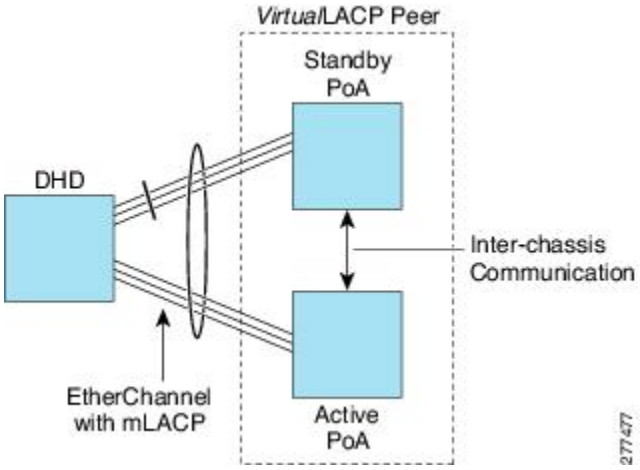
- **ethernet mac-flush notification mirp**
- **show ethernet service instance id mac-tunnel**
- **errdisable recovery cause mlacp**

Information About mLACP

Overview of Multichassis EtherChannel

In Multichassis EtherChannel (MCEC), the DHD is dual-homed to two upstream PoAs. The DHD is incapable of running any loop prevention control protocol such as Multiple Spanning Tree (MST). Therefore, another mechanism is required to prevent forwarding loops over the redundant setup. One method is to place the DHD's uplinks in a LAG, commonly referred to as EtherChannel. This method assumes that the DHD is capable of running only IEEE 802.3ad LACP for establishing and maintaining the LAG.

LACP, as defined in IEEE 802.3ad, is a link-level control protocol that allows the dynamic negotiation and establishment of LAGs. An extension of the LACP implementation to PoAs is required to convey to a DHD that it is connected to a single virtual LACP peer and not to two disjointed devices. This extension is called Multichassis LACP or mLACP. The figure below shows this setup.



The PoAs forming a virtual LACP peer, from the perspective of the DHD, are defined as members of a redundancy group. For the PoAs in a redundancy group to appear as a single device to the DHD, the states between them must be synchronized through the Interchassis Communication Protocol (ICCP), which provides a control-only interchassis communication channel (ICC).

In Cisco IOS Release 12.2(33)SRE, the system functions in active/standby redundancy mode. In this mode DHD uplinks that connect to only a single PoA can be active at any time. The DHD recognizes one PoA as active and the other as standby but does not preclude a given PoA from being active for one DHD and standby for another. This capability allows two PoAs to perform load sharing for different services.

Interactions with the MPLS Pseudowire Redundancy Mechanism

The network setup shown in the figure above can be used to provide provider edge (PE) node redundancy for Virtual Private LAN Service (VPLS) and Virtual Private Wire Service (VPWS) deployments over Multiprotocol Label Switching (MPLS). In these deployments, the uplinks of the PoAs host the MPLS pseudowires that provide redundant connectivity over the core to remote PE nodes. Proper operation of the network requires interaction between the redundancy mechanisms employed on the attachment circuits (for example, mLACP) and those employed on the MPLS pseudowires. This interaction ensures the state (active or standby) is synchronized between the attachment circuits and pseudowires for a given PoA.

RFC 4447 introduced a mechanism to signal pseudowire status via the Link Distribution Protocol (LDP) and defined a set of status codes to report attachment circuit as well as pseudowire fault information. The Preferential Forwarding Status bit (*draft-ietf-pwe3-redundancy-bit*) definition proposes to extend these codes to include two bits for pseudowire redundancy applications:

- Preferential forwarding status: active or standby
- Request pseudowire switchover

The draft also proposes two modes of operation:

- Independent mode--The local PE decides on its pseudowire status independent of the remote PE.
- Primary and secondary modes--One of the PEs determines the state of the remote side through a handshake mechanism.

For the mLACP feature, operation is based on the independent mode. By running ICC between the PoAs, only the preferential forwarding status bit is required; the request pseudowire switchover bit is not used.

The local pseudowire status (active or standby) is determined independently by the PoAs in a redundancy group and then relayed to the remote PEs in the form of a notification. Similarly, the remote PEs perform their own selection of their pseudowire status and notify the PoAs on the other side of the core.

After this exchange of local states, the pseudowires used for traffic forwarding are those selected to be active independently on both local and remote ends.

The attachment circuit redundancy mechanism determines and controls the pseudowire redundancy mechanism. mLACP determines the status of the attachment circuit on a given PoA according to the configured LACP system and port priorities, and then the status of the pseudowires on a given PoA is synchronized with that of the local attachment circuits. This synchronization guarantees that the PoA with the active attachment circuits has its pseudowires active. Similarly, the PoA with the standby attachment circuits has its pseudowires in standby mode. By ensuring that the forwarding status of the attachment circuits is synchronized with that of the pseudowires, the need to forward data between PoA nodes within a redundancy group can be avoided. This synchronization saves platform bandwidth that would otherwise be wasted on inter-PoA data forwarding in case of failures.

Redundancy Mechanism Processes

The Carrier Ethernet redundancy solution should include the following processes (and how they apply to the mLACP solution):

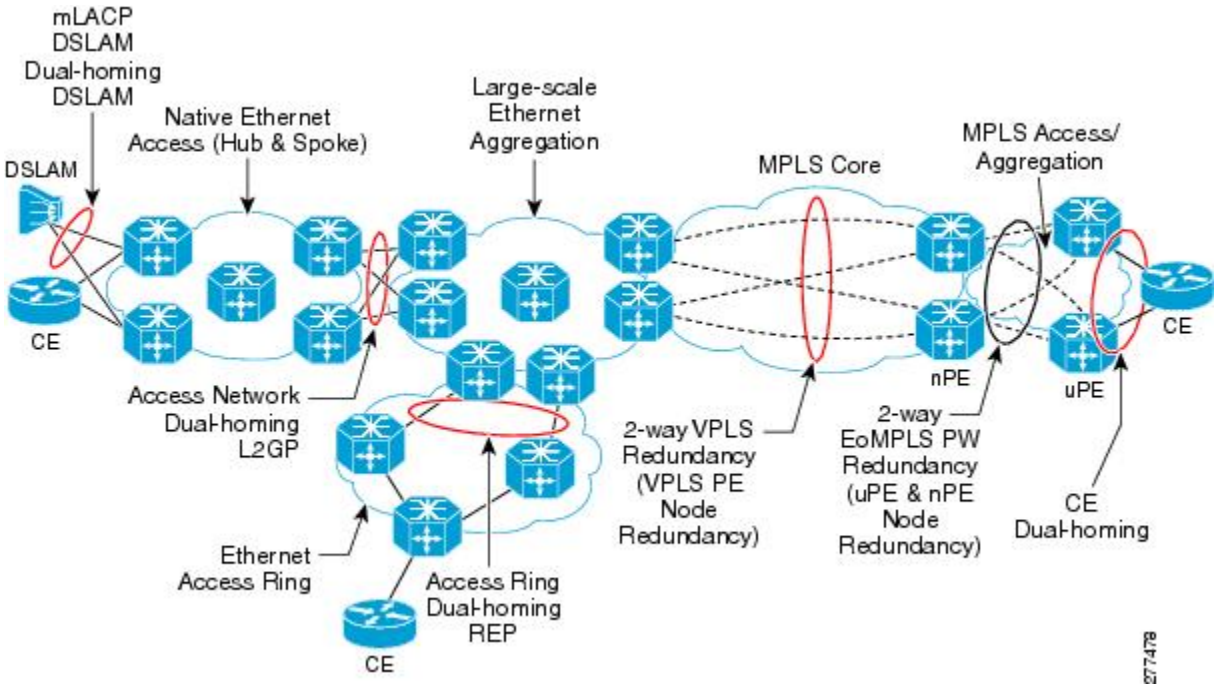
- Attachment circuit active or standby status selection--This selection can be performed by the access node or network, the aggregation node, or combination of the two. For mLACP, the attachment circuit status selection is determined through collaboration between the DHD and the PoAs.

- Pseudowire forwarding status notification--This notification is mandatory for mLACP operation in VPWS and VPLS deployments; that is, when the PoA uplinks employ pseudowire technology. When the PoAs decide on either an active or standby role, they need to signal the status of the associated pseudowires to the PEs on the far end of the network. For MPLS pseudowires, this is done using LDP.
- MAC flushing indication--This indication is mandatory for any redundancy mechanism in order to speed convergence time and eliminate potential traffic failure. The mLACP redundancy mechanism should be integrated with relevant 802.1Q/802.1ad/802.1ah MAC flushing mechanisms as well as MAC flushing mechanisms for VPLS.

Note Failure occurs when incoming traffic is dropped without informing the source that the data did not reach its intended recipient. Failure can be detected only when lost traffic is monitored.

- Active VLAN notification--For mLACP, this notification is not required as long as the PoAs follow the active/standby redundancy model.

The figure below shows redundancy mechanisms in Carrier Ethernet networks.



Dual-Homed Topology Using mLACP

The mLACP feature allows the LACP state machine and protocol to operate in a dual-homed topology. The mLACP feature decouples the existing LACP implementation from the multichassis specific requirements, allowing LACP to maintain its adherence to the IEEE 802.3ad standard. The mLACP feature exposes a single virtual instance of IEEE 802.3ad to the DHD for each redundancy group. The virtual LACP instance interoperates with the DHD according to the IEEE 802.3ad standard to form LAGs spanning two or more chassis.

LACP and 802.3ad Parameter Exchange

In IEEE 802.3ad, the concatenation of the LACP system MAC address and system priority form an LACP system ID (8 bytes). The system ID is formed by taking the two-byte system priority value as the most significant two octets of the system ID. The system MAC address makes up the remainder of the system ID (octets 3 to 8). System ID priority comparisons are based on the lower numerically valued ID.

To provide the highest LACP priority, the mLACP module communicates the system MAC address and priority values for the given redundancy group to its redundancy group peer(s) and vice versa. The mLACP then chooses the lowest system ID value among the PoAs in the given redundancy group to use as the system ID of the virtual LACP instance of the redundancy group.

Cisco IOS Release 12.2(33)SRE introduces two LACP configuration commands to specify the system MAC address and system priority used for a given redundancy group: **mlacp system-mac** *mac-address* and **mlacp system-priority** *priority-value*. These commands provide better settings to determine which side of the attachment circuit will control the selection logic of the LAG. The default value for the system MAC address is the chassis backplane default MAC address. The default value for the priority is 32768.

Port Identifier

IEEE 802.3ad uses a 4-byte port identifier to uniquely identify a port within a system. The port identifier is the concatenation of the port priority and port number (unique per system) and identifies each port in the system. Numerical comparisons between port IDs are performed by unsigned integer comparisons where the 2-byte Port Priority field is placed in the most significant two octets of the port ID. The 2-byte port number makes up the third and fourth octets. The mLACP feature coordinates the port IDs for a given redundancy group to ensure uniqueness.

Port Number

A port number serves as a unique identifier for a port within a device. The LACP port number for a port is equal to the port's ifIndex value (or is based on the slot and subslot identifiers on the Cisco 7600 router).

LACP relies on port numbers to detect rewiring. For multichassis operation, you must enter the **mlacp node-id** *node-id* command to coordinate port numbers between the two PoAs in order to prevent overlap.

Port Priority

Port priority is used by the LACP selection logic to determine which ports should be activated and which should be left in standby mode when there are hardware or software limitations on the maximum number of links allowed in a LAG. For multichassis operation in active/standby redundancy mode, the port priorities for all links connecting to the active PoA must be higher than the port priorities for links connecting to the standby PoA. These port priorities can either be guaranteed through explicit configuration or the system can automatically adjust the port priorities depending on selection criteria. For example, select the PoA with the highest port priority to be the active PoA and dynamically adjust the priorities of all other links with the same port key to an equal value.

In Cisco IOS Release 12.2(33)SRE, the mLACP feature supports only the active/standby redundancy model. The LACP port priorities of the individual member links should be the same for each link belonging to the LAG of a given PoA. To support this requirement, the **mlacp lag-priority** command is implemented in interface configuration mode in the command-line interface (CLI). This command sets the LACP port priorities for all the local member links in the LAG. Individual member link LACP priorities (configured by the **lacp port-priority** command) are ignored on links belonging to mLACP port channels.

The **mlacp lag-priority** command may also be used to force a PoA failover during operation in the following two ways:

- Set the active PoA's LAG priority to a value greater than the LAG priority on the standby PoA. This setting results in the quickest failover because it requires the fewest LACP link state transitions on the standby links before they turn active.
- Set the standby PoA's LAG priority to a value numerically less than the LAG priority on the active PoA. This setting results in a slightly longer failover time because standby links have to signal OUT_OF_SYNC to the DHD before the links can be brought up and go active.

In some cases, the operational priority and the configured priority may differ when using dynamic port priority management to force failovers. In this case, the configured version will not be changed unless the port channel is operating in nonrevertive mode. Enter the **show lacp multichassis port-channel** command to view the current operational priorities. The configured priority values can be displayed by using the **show running-config** command.

Multichassis Considerations

Because LACP is a link layer protocol, all messages exchanged over a link contain information that is specific and local to that link. The exchanged information includes:

- System attributes--priority and MAC address
- Link attributes--port key, priority, port number, and state

When extending LACP to operate over a multichassis setup, synchronization of the protocol attributes and states between the two chassis is required.

System MAC Address

LACP relies on the system MAC address to determine the identity of the remote device connected over a particular link. Therefore, to mask the DHD from its connection to two disjointed devices, coordination of the system MAC address between the two PoAs is essential. In Cisco IOS software, the LACP system MAC address defaults to the ROM backplane base MAC address and cannot be changed by configuration. For multichassis operation the following two conditions are required:

- System MAC address for each PoA should be communicated to its peer--For example, the PoAs elect the MAC address with the lower numeric value to be the system MAC address. The arbitration scheme must resolve to the same value. Choosing the lower numeric MAC address has the advantage of providing higher system priority.
- System MAC address is configurable--The system priority depends, in part, on the MAC address, and a service provider would want to guarantee that the PoAs have higher priority than the DHD (for example, if both DHD and PoA are configured with the same system priority and the service provider has no control over DHD). A higher priority guarantees that the PoA port priorities take precedence over the DHD's port priority configuration. If you configure the system MAC address, you must ensure that the addresses are uniform on both PoAs; otherwise, the system will automatically arbitrate the discrepancy, as when a default MAC address is selected.

System Priority

LACP requires that a system priority be associated with every device to determine which peer's port priorities should be used by the selection logic when establishing a LAG. In Cisco IOS software, this parameter is

configurable through the CLI. For multichassis operation, this parameter is coordinated by the PoAs so that the same value is advertised to the DHD.

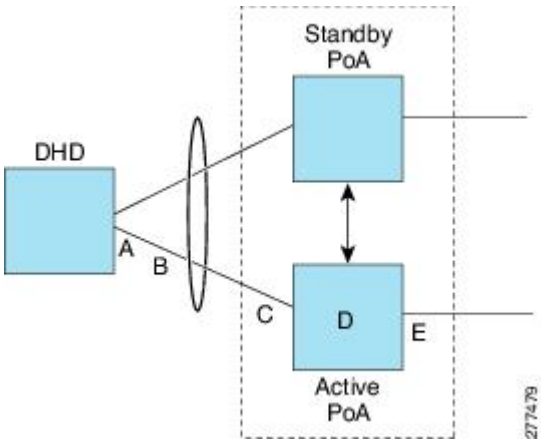
Port Key

The port key indicates which links can form a LAG on a given system. The key is locally significant to an LACP system and need not match the key on an LACP peer. Two links are candidates to join the same LAG if they have the same key on the DHD and the same key on the PoAs; however, the key on the DHD is not required to be the same as the key on the PoAs. Given that the key is configured according to the need to aggregate ports, there are no special considerations for this parameter for multichassis operation.

Failure Protection Scenarios

The mLACP feature provides network resiliency by protecting against port, link, and node failures. These failures can be categorized into five types. The figure below shows the failure points in a network, denoted by the letters A through E.

- A--Failure of the uplink port on the DHD
- B--Failure of the Ethernet link
- C--Failure of the downlink port on the active PoA
- D--Failure of the active PoA node
- E--Failure of the active PoA uplinks



When any of these faults occur, the system reacts by triggering a switchover from the active PoA to the standby PoA. The switchover involves failing over the PoA's uplinks and downlinks simultaneously.

Failure points A and C are port failures. Failure point B is an Ethernet link failure and failure point D is a node failure. Failure point E can represent one of four different types of uplink failures when the PoAs connect to an MPLS network:

- Pseudowire failure--Monitoring individual pseudowires (for example, using VCCV-BFD) and, upon a pseudowire failure, declare uplink failure for the associated service instances.
- Remote PE IP path failure--Monitoring the IP reachability to the remote PE (for example, using IP Route-Watch) and, upon route failure, declare uplink failure for all associated service instances.

- LSP failure--Monitoring the LSP to a given remote PE (for example, using automated LSP-Ping) and, upon LSP failure, declare uplink failure for all associated service instances.
- PE isolation--Monitoring the physical core-facing interfaces of the PE. When all of these interfaces go down, the PE effectively becomes isolated from the core network, and the uplink failure is declared for all affected service instances.

As long as the IP/MPLS network employs native redundancy and resiliency mechanisms such as MPLS fast reroute (FRR), the mLACP solution is sufficient for providing protection against PE isolation. Pseudowire, LSP, and IP path failures are managed by the native IP/MPLS protection procedures. That is, interchassis failover via mLACP is triggered only when a PE is completely isolated from the core network, because native IP/MPLS protection mechanisms are rendered useless. Therefore, failure point E is used to denote PE isolation from the core network.

Note The set of core-facing interfaces that should be monitored are identified by explicit configuration. The set of core-facing interfaces must be defined independently per redundancy group. Failure point E (unlike failure point A, B, or C) affects and triggers failover for all the multichassis LAGs configured on a given PoA.

Operational Variants

LACP provides a mechanism by which a set of one or more links within a LAG are placed in standby mode to provide link redundancy between the devices. This redundancy is normally achieved by configuring more ports with the same key than the number of links a device can aggregate in a given LAG (due to hardware or software restrictions, or due to configuration). For example, for active/standby redundancy, two ports are configured with the same port key, and the maximum number of allowed links in a LAG is configured to be 1. If the DHD and PoAs are all capable of restricting the number of links per LAG by configuration, three operational variants are possible.

DHD-based Control

The value of PoAs must be greater than the value of DHD. In DHD-based control, maximum number of links per bundle should be one. The PoAs must be configured to limit the maximum number of links per bundle to be greater than one. Thus, the selection of the active/standby link is the responsibility of the DHD. Which link is designated active and which is marked standby depends on the relative port priority, as configured on the system with the higher system priority. A PoA configured with a higher system priority can still determine the selection outcome. The DHD makes the selection and places the link with lower port priority in standby mode.

To accommodate DHD-controlled failover, the DHD must be configured with the max-bundle value equal to a number of links (L), where L is the fewest number of links connecting the DHD to a PoA. The max-bundle value restricts the DHD from bundling links to both PoAs at the same time (active/active). Although the DHD controls the selection of active/standby links, the PoA can still dictate the individual member link priorities by configuring the PoA's virtual LACP instance with a lower system priority value than the DHD's system priority.

The DHD control variant must be used with a PoA minimum link threshold failure policy where the threshold is set to L (same value for L as described above). A minimum link threshold must be configured on each of the PoAs because an A, B, or C link failure that does not trigger a failover (minimum link threshold is still satisfied) causes the DHD to add one of the standby links going to the standby PoA to the bundle. This added link results in the unsupported active/active scenario.

Note DHD control does not use the mLACP hot-standby state on the standby PoA, which results in higher failover times than the other variants.

DHD control eliminates the split brain problem on the attachment circuit side by limiting the DHD's attempts to bundle all the links.

PoA Control

In PoA control, the PoA is configured to limit the maximum number of links per bundle to be equal to the number of links (L) going to the PoA. The DHD is configured with that parameter set to some value greater than L. Thus, the selection of the active/standby links becomes the responsibility of the PoA.

Shared Control (PoA and DHD)

In shared control, both the DHD and the PoA are configured to limit the maximum number of links per bundle to L--the number of links going to the PoA. In this configuration, each device independently selects the active/standby link. Shared control is advantageous in that it limits the split-brain problem in the same manner as DHD control, and shared control is not susceptible to the active/active tendencies that are prevalent in DHD control. A disadvantage of shared control is that the failover time is determined by both the DHD and the PoA, each changing the standby links to SELECTED and waiting for each of the WAIT_WHILE_TIMERs to expire before moving the links to IN_SYNC. The independent determination of failover time and change of link states means that both the DHD and PoAs need to support the LACP fast-switchover feature in order to provide a failover time of less than one second.

mLACP Failover

The mLACP forces a PoA failover to the standby PoA when one of the following failures occurs:

- Failure of the DHD uplink port, Ethernet link, or downlink port on the active PoA—A policy failover is triggered via a configured failover policy and is considered a forced failover. When the number of active and SELECTED links to the active PoA goes below the configured minimum threshold, mLACP forces a failover to the standby PoA's member links. This minimum threshold is configured using the **lacp min-links** command in interface configuration mode. The PoAs determine the failover independent of the operational control variant in use.
- Failure of the active PoA—This failure is detected by the standby PoA. mLACP automatically fails over to standby because mLACP on the standby PoA is notified of failure via ICRM and brings up its local member links. In the DHD-controlled variant, this failure looks the same as a total member link failure, and the DHD activates the standby links.
- Failure of the active PoA uplinks—mLACP is notified by ICRM of PE isolation and relinquishes its active member links. This failure is a "forced failover" and is determined by the PoAs independent of the operational control variant in use.

Dynamic Port Priority

The default failover mechanism uses dynamic port priority changes on the local member links to force the LACP selection logic to move the required standby link(s) to the SELECTED and Collecting_Distributing state. This state change occurs when the LACP actor port priority values for all affected member links on the currently active PoA are changed to a higher numeric value than the standby PoA's port priority (which gives

the standby PoA ports a higher claim to bundle links). Changing the actor port priority triggers the transmission of an mLACP Port Config Type-Length-Value (TLV) message to all peers in the redundancy group. These messages also serve as notification to the standby PoA(s) that the currently active PoA is attempting to relinquish its role. The LACP then transitions the standby link(s) to the SELECTED state and moves all the currently active links to STANDBY.

Dynamic port priority changes are not automatically written back to the running configuration or to the NVRAM configuration. If you want the current priorities to be used when the system reloads, the **mlacp lag-priority** command must be used and the configuration must be saved.

Revertive and Nonrevertive Modes

Dynamic port priority functionality is used by the mLACP feature to provide both revertive mode and nonrevertive mode. The default operation is revertive, which is the default behavior in single chassis LACP. Nonrevertive mode can be enabled on a per port-channel basis by using the **lacp failover non-revertive**command in interface configuration mode. In Cisco IOS Release 12.2(33)SRE this command is supported only for mLACP.

Nonrevertive mode is used to limit failover and, therefore, possible traffic loss. Dynamic port priority changes are utilized to ensure that the newly activated PoA remains active after the failed PoA recovers.

Revertive mode operation forces the configured primary PoA to return to active state after it recovers from a failure. Dynamic port priority changes are utilized when necessary to allow the recovering PoA to resume its active role.

Brute Force Shutdown

Note This feature is not applicable for Cisco ASR 903 RSP3 Module.

A brute-force shutdown is a forced failover mechanism to bring down the active physical member link interface(s) for the given LAG on the PoA that is surrendering its active status. The port-channel and any remaining active member link goes to an “err-disabled” state. This mechanism does not depend on the DHD’s ability to manage dynamic port priority changes and compensates for deficiencies in the DHD’s LACP implementation.

The brute-force shutdown changes the status of each member link to ADMIN_DOWN to force the transition of the standby links to the active state. Note that this process eliminates the ability of the local LACP implementation to monitor the link state.

The brute-force shutdown operates in revertive mode, so dynamic port priorities cannot be used to control active selection. The brute-force approach is configured by the **lacp failover brute-force** command in interface configuration mode. This command is not allowed in conjunction with a nonrevertive configuration.

Peer Monitoring with Interchassis Redundancy Manager

There are two ways in which a peer can be monitored with Interchassis Redundancy Manager (ICRM):

- Routewatch (RW)--This method is the default.
- Bidirectional Forwarding Detection (BFD)--You must configure the redundancy group with the **monitor peer bfd** command.

Note In Cisco IOS XE Everest 16.5.1 release, RSP3 Module only supports single-hop BFD, hence only single-hop BFD is applicable for mLACP peer monitoring.

Note For stateful switchover (SSO) deployments (with redundant support in the chassis), BFD monitoring and a static route for the ICCP connection are required to prevent "split brain" after an SSO failover.

For each redundancy group, for each peer (member IP), a monitoring adjacency is created. If there are two peers with the same IP address, the adjacency is shared regardless of the monitoring mode. For example, if redundancy groups 1 and 2 are peered with member IP 10.10.10.10, there is only one adjacency to 10.10.10.10, which is shared in both redundancy groups. Furthermore, redundancy group 1 can use BFD monitoring while redundancy group 2 is using RW.

Note BFD is completely dependent on RW--there must be a route to the peer for ICRM to initiate BFD monitoring. BFD implies RW and sometimes the status of the adjacency may seem misleading but is accurately representing the state. Also, if the route to the peer PoA is not through the directly connected (back-to-back) link between the systems, BFD can give misleading results.

An example of output from the **show redundancy interchassis** command follows:

```
Device# show redundancy interchassis
Redundancy Group 1 (0x1)
  Applications connected: mLACP
  Monitor mode: Route-watch
  member ip: 201.0.0.1 'mlacp-201', CONNECTED
    Route-watch for 201.0.0.1 is UP
    mLACP state: CONNECTED
ICRM fast-failure detection neighbor table
  IP Address       Status Type Next-hop IP      Interface
  ==========       ====== ==== ===========      =========
  201.0.0.1        UP     RW
```

To interpret the adjacency status displayed by the **show redundancy interchassis** command, refer to the table below.

Table 3: Status Information from the show redundancy interchassis command

Adjacency Type	Adjacency Status	Meaning
RW	DOWN	RW or BFD is configured, but there is no route for the given IP address.
RW	UP	RW or BFD is configured. RW is up, meaning there is a valid route to the peer. If BFD is configured and the adjacency status is UP, BFD is probably not configured on the interface of the route's adjacency.

Adjacency Type	Adjacency Status	Meaning
BFD	DOWN	BFD is configured. A route exists and the route's adjacency is to an interface that has BFD enabled. BFD is started but the peer is down. The DOWN status can be because the peer is not present or BFD is not configured on the peer's interface.
BFD	UP	BFD is configured and operational.

Note If the adjacency type is "BFD," RW is UP regardless of the BFD status.

MAC Flushing Mechanisms

When mLACP is used to provide multichassis redundancy in multipoint bridged services (for example, VPLS), there must be a MAC flushing notification mechanism in order to prevent potential traffic failure.

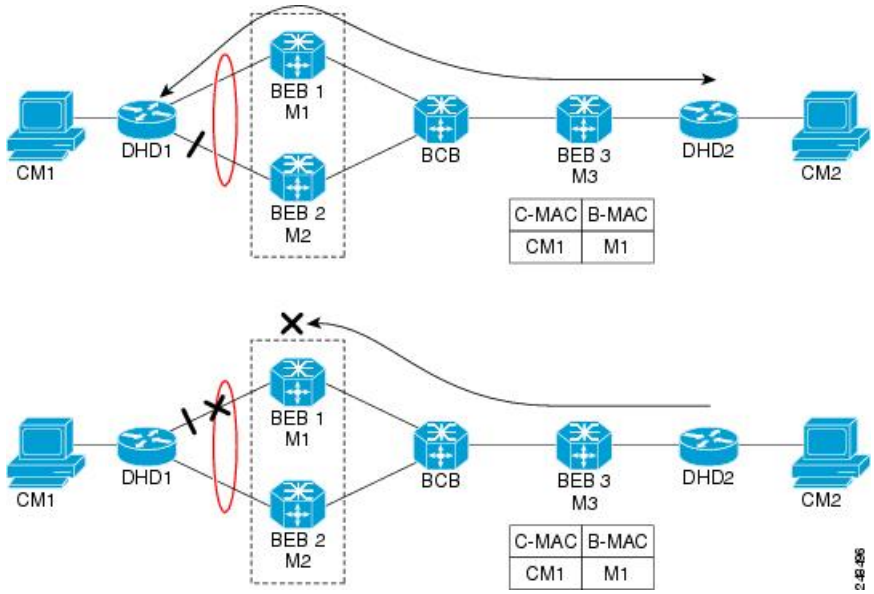
At the failover from a primary PoA to a secondary PoA, a service experiences traffic failure when the DHD in question remains inactive and while other remote devices in the network are attempting to send traffic to that DHD. Remote bridges in the network have stale MAC entries pointing to the failed PoA and direct traffic destined to the DHD to the failed PoA, where the traffic is dropped. This failure continues until the remote devices age out their stale MAC address table entries (which typically takes five minutes). To prevent this anomaly, the newly active PoA, which has taken control of the service, transmits a MAC flush notification message to the remote devices in the network to flush their stale MAC address entries for the service in question.

The exact format of the MAC flushing message depends on the nature of the network transport: native 802.1Q/802.1ad Ethernet, native 802.1ah Ethernet, VPLS, or provider backbone bridge (PBB) over VPLS. Furthermore, in the context of 802.1ah, it is important to recognize the difference between mechanisms used for customer-MAC (C-MAC) address flushing versus bridge-MAC (B-MAC) address flushing.

The details of the various mechanisms are discussed in the following sections.

Multiple I-SID Registration Protocol

Multiple I-SID Registration Protocol (MIRP) is enabled by default on 802.1ah service instances. The use of MIRP in 802.1ah networks is shown in the figure below.



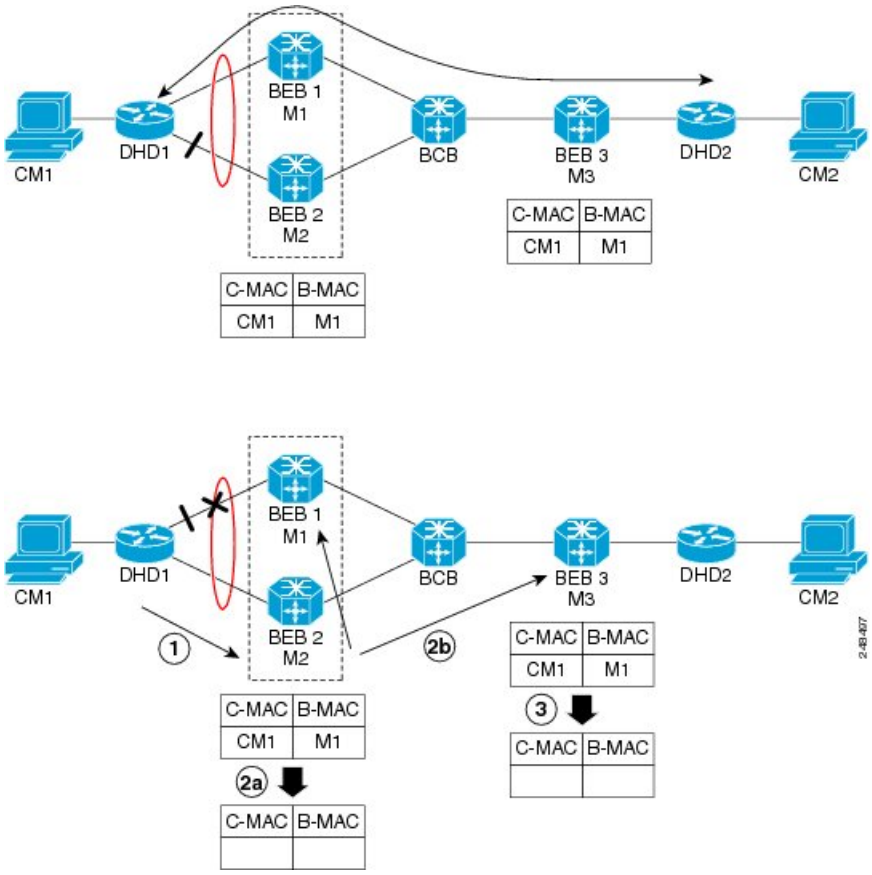
Device DHD1 is dual-homed to two 802.1ah backbone edge bridges (BEB1 and BEB2). Assume that initially the primary path is through BEB1. In this configuration BEB3 learns that the host behind DHD1 (with MAC address CM1) is reachable via the destination B-MAC M1. If the link between DHD1 and BEB1 fails and the host behind DHD1 remains inactive, the MAC cache tables on BEB3 still refer to the BEB1 MAC address even though the new path is now via BEB2 with B-MAC address M2. Any bridged traffic destined from the host behind DHD2 to the host behind DHD1 is wrongfully encapsulated with B-MAC M1 and sent over the MAC tunnel to BEB1, where the traffic fails.

To circumvent the traffic failure problem when the link between DHD1 and BEB1 fails, BEB2 performs two tasks:

- Flushes its own MAC address table for the service or services in question.
- Transmits an MIRP message on its uplink to signal the far end BEB (BEB3) to flush its MAC address table. Note that the MIRP message is transparent to the backbone core bridges (BCBs). The MIRP message is processed on a BEB because only BCBs learn and forward based on B-MAC addresses and they are transparent to C-MAC addresses.

Note MIRP triggers C-MAC address flushing for both native 802.1ah and PBB over VPLS. This is not applicable for Cisco ASR 903 RSP3 Module.

The figure below shows the operation of the MIRP.



The MIRP has not been defined in IEEE but is expected to be based on the IEEE 802.1ak Multiple Registration Protocol (MRP). MRP maintains a complex finite state machine (FSM) for generic attribute registration. In the case of MIRP, the attribute is an I-SID. As such, MIRP provides a mechanism for BEBs to build and prune a per I-SID multicast tree. The C-MAC flushing notification capability of MIRP is a special case of attribute registration in which the device indicates that an MIRP declaration is "new," meaning that this notification is the first time a BEB is declaring interest in a particular I-SID.

LDP MAC Address Withdraw

When the mLACP feature is used for PE redundancy in traditional VPLS (that is, not PBB over VPLS), the MAC flushing mechanism is based on the LDP MAC Address Withdraw message as defined in RFC 4762.

The required functional behavior is as follows: Upon a failover from the primary PoA to the standby PoA, the standby PoA flushes its local MAC address table for the affected services and generates the LDP MAC Address Withdraw messages to notify the remote PEs to flush their own MAC address tables. One message is generated for each pseudowire in the affected virtual forwarding instances (VFIs).

mLACP and L3VPN Static Routes Overview

In a network where L3VPN and Cisco multichassis Link Aggregation Control Protocol (mLACP) features are enabled, and logical port channels have subinterfaces that are not configured with Multichassis-LAG (MC-LAG), the subinterfaces on both active and standby PoAs are in the active (UP) state.

The static routes are advertised through both active and standby PoAs to the core MPLS, because all port channel subinterfaces are in active (UP) state on active and standby PoAs.

To prevent the static routes being advertised on a standby PoA, when a PoA moves to an inactive state, the static routes are blocked on all Layer 3 port-channel subinterfaces. When a PoA moves to an active state, static routes are allowed on all Layer 3 port-channel subinterfaces.

To block the standby PoA from advertising static routes to MPLS, MC-LAG notifies the platform manager about the change in the PoA state. The platform manager shuts down all subinterfaces that are associated with the standby PoA.

To allow the static routes on subinterfaces, when a PoA moves to active state, the platform manager activates all subinterfaces that are associated with the active PoA.

The supported scale numbers are 1k BDIs and 1k VRFs.

mLACP Redundancy

The mLACP feature provides network resiliency by protecting the network against port, link, and node failures. These failures can be categorized into five types.

- Failure of the uplink port on the dual-homed device (DHD)
- Failure of the Ethernet link
- Failure of the downlink port on the active PoA
- Failure of the active PoA
- Failure of active PoA when isolated from the core network

When a PoA moves to active or standby redundancy mode, the mLACP triggers a registered call from the platform manager to block or unblock the static routes on subinterfaces that are associated with the port channel of PoA.

Enabling MC-LAG for L3VPN

To enable MC-LAG for L3VPN, perform the following:

```
configure terminal
  port-channel mc-lag

STBY-PoA
BDI101                 121.1.1.1       YES manual administratively down down
BDI102                 122.1.1.1       YES manual administratively down down

Active PoA
BDI101                 121.1.1.1       YES manual up                    up
BDI102                 122.1.1.1       YES manual up                    up
```

Show Commands

You can use the following show commands:

- Show etherchannel summary
- Show lacp multi-chassis group

- Show lacp multi-chassis port-channel
- Show redundancy interchassis
- Show bfd neighbors
- Show ip route vrf
- Show ip cef vrf
- Show ip bgp vpnv4 vrf vpn_1 sum
- Show bfd nei vrf vpn_1
- Show ip bgp vpnv4 all labels
- Show bfd neighbor vrf vpn_1 client bgp
- Show ip bgp summary or neighbors
- Show platform hardware pp active efp database

Debug Commands

You can use the following debug commands to troubleshoot your configuration:

- debug lacp event
- debug lacp fsm
- debug lacp multi-chassis all
- debug lacp etherchannel
- debug ethernet etherchannel
- debug redundancy interchassis
- debug mpls ldp iccp

How to Configure mLACP

Configuring Interchassis Group and Basic mLACP Commands (Global Redundancy Group Configuration)

Perform this task to set up the communication between multiple PoAs and to configure them in the same group.

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 **redundancy**

Example:

```
Router(config)# redundancy
```

Enters redundancy configuration mode.

Step 4 **interchassis group** *group-id*

Example:

```
Router(config-red)# interchassis group 50
```

Configures an interchassis group within the redundancy configuration mode and enters interchassis redundancy mode.

Step 5 **monitor peer bfd**

Example:

```
Router(config-r-ic)# monitor peer bfd
```

Configures the BFD option to monitor the state of the peer. The default option is route-watch.

Step 6 **member ip** *ip-address*

Example:

```
Router(config-r-ic)# member ip 172.3.3.3
```

Configures the IP address of the mLACP peer member group.

Step 7 **mlacp node-id** *node-id*

Example:

```
Router(config-r-ic)# mlacp node-id 5
```

Defines the node ID used in the LACP Port ID field by this member of the mLACP redundancy group.

- The valid range is 0 to 7, and the value should be different from the peer values.

Step 8 **mlacp system-mac** *mac-address*

Example:

```
Router(config-r-ic)# mlacp system-mac aa12.be45.d799
```

Defines and advertises the system MAC address value to the mLACP members of the redundancy group for arbitration.

- The format of the *mac-address* argument must be in standard MAC address format: aabb.ccdd.eeff.

Step 9 **mlacp system-priority** *priority-value*

Example:

```
Router(config-r-ic)# mlacp system-priority 100
```

Defines the system priority advertised to the other mLACP members of the redundancy group.

- System priority values are 1 to 65535. Default value is 32768.
- The assigned values should be lower than the DHD.

Step 10 **backbone interface** *type number*

Example:

```
Router(config-r-ic)#
backbone interface GigabitEthernet2/3
```

Defines the backbone interface for the mLACP configuration.

Step 11 **end**

Example:

```
Router(config-r-ic)# end
```

Returns the CLI to privileged EXEC mode.

Configuring the mLACP Interchassis Group and Other Port-Channel Commands

Perform this task to set up mLACP attributes specific to a port channel. The **mlacp interchassis group** command links the port-channel interface to the interchassis group that was created in the previous Configuring Interchassis Group and Basic mLACP Commands (Global Redundancy Group Configuration) , on page 65.

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** *port-channel- number*

Example:

```
Router(config)# interface port-channel1
```

Configures the port channel and enters interface configuration mode.

Step 4 **lacp max-bundle** *max-bundles*

Example:

```
Router(config-if)# lacp max-bundle 4
```

Configures the max-bundle links that are connected to the PoA. The value of the *max-bundles* argument should not be less than the total number of links in the LAG that are connected to the PoA.

- Determines whether the redundancy group is under DHD control, PoA control, or both.
- Range is 1 to 8. Default value is 8.

Step 5 **lacp failover** {**brute-force**| **non-revertive**}

Example:

```
Router(config-if)# lacp failover brute-force
```

Sets the mLACP switchover to nonrevertive or brute force. This command is optional.

Note Brute-force failover is not supported for RSP3 module.

- Default value is revertive (with 180-second delay).
- If you configure brute force, a minimum link failure for every mLACP failure occurs or the dynamic lag priority value is modified.

Step 6 **mlacp interchassis group** *group-id*

Example:

```
Router(config-red)# mlacp interchassis group 230
```

Specifies that the port channel is an mLACP port channel. The *group-id* should match the configured redundancy group.

Step 7 **end**

Example:

```
Router(config-r-ic)# end
```

Returns the CLI to privileged EXEC mode.

Configuring Redundancy for VPWS

For more information on VPWS, see EVPN Virtual Private Wire Service (VPWS) Single Homed.

Perform this task to provide Layer 2 VPN service redundancy for VPWS.

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 **pseudowire-class** *pw-class-name*

Example:

```
Router(config)# pseudowire-class ether-pw
```

Specifies the name of a Layer 2 pseudowire class and enters pseudowire class configuration mode.

Step 4 **encapsulation mpls**

Example:

```
Router(config-pw-class)# encapsulation mpls
```

Specifies that MPLS is used as the data encapsulation method for tunneling Layer 2 traffic over the pseudowire.

Step 5 **status peer topology dual-homed**

Example:

```
Router(config-pw-class)# status peer topology dual-homed
```

Enables the reflection of the attachment circuit status onto both the primary and secondary pseudowires. This condition is necessary if the peer PEs are connected to a dual-homed device.

Step 6 **exit**

Example:

```
Router(config-pw-class)# exit
```

Exits pseudowire class configuration mode.

Step 7 **interface port-channel** *port-channel-number*

Example:

```
Router(config)# interface port-channel1
```

Configures the port channel and enters interface configuration mode.

Step 8 **no ip address**

Example:

```
Router(config-if)# no ip address
```

Specifies that the VLAN interface does not have an IP address assigned to it.

Step 9 **lacp fast-switchover**

Example:

```
Router(config-if)# lacp fast-switchover
```

Enables LACP 1-to-1 link redundancy.

Step 10 **lacp max-bundle** *max-bundles*

Example:

```
Router(config-if)# lacp max-bundle 4
```

Configures the max-bundle links that are connected to the PoA. The value of the *max-bundles*argument should not be less than the total number of links in the LAG that are connected to the PoA.

- Determines whether the redundancy group is under DHD control, PoA control, or both.
- Range is 1 to 8. Default value is 8.

Step 11 **mlacp interchassis group** *group-id*

Example:

```
Router(config-red)# mlacp interchassis group 230
```

Specifies that the port channel is an mLACP port channel.

- The *group-id* should match the configured redundancy group.

Step 12 **exit**

Example:

```
Router(config-red)# exit
```

Exits redundancy configuration mode.

Step 13 **interface port-channel** *port-channel-number*

Example:

```
Router(config)# interface port-channel1
```

Configures the port channel and enters interface configuration mode.

Step 14 **service instance** *id* **ethernet** [*evc-name*]

Example:

```
Router(config-if)# service instance 1 ethernet
```

Configures an Ethernet service instance.

Step 15 **encapsulation dot1q** *vlan-id* [**,** *vlan-id* [**-** *vlan-id*]]

Example:

```
Router(config-if-srv)# encapsulation dot1q 100
```

Enables IEEE 802.1Q encapsulation of traffic on a specified subinterface in a VLAN.

Step 16 **xconnect** *peer-ip-address vc-id* {**encapsulation mpls** | **pw-class** *pw-class-name*} [**pw-class** *pw-class-name*] [**sequencing** {**transmit** | **receive** | **both**}]

Example:

```
Router(config-if)# xconnect 10.0.3.201 123 pw-class ether-pw
```

Binds an attachment circuit to a pseudowire.

Step 17 **backup peer** *peer-router-ip-addr vcid* [**pw-class** *pw-class-name*] [**priority** *value*]

Example:

```
Router(config-if)# backup peer 10.1.1.1 123 pw-class ether-pw
```

Specifies a redundant peer for a pseudowire virtual circuit.

Step 18 **end**

Example:

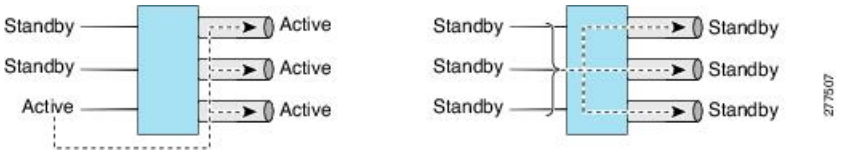
```
Router(config-if)# end
```

Returns the CLI to privileged EXEC mode.

Configuring Redundancy for VPLS

Coupled and Decoupled Modes for VPLS

VPLS can be configured in either coupled mode or decoupled mode. Coupled mode is when at least one attachment circuit in VFI changes state to active, all pseudowires in VFI advertise active. When all attachment circuits in VFI change state to standby, all pseudowires in VFI advertise standby mode. See the figure below.



VPLS decoupled mode is when all pseudowires in the VFI are always active and the attachment circuit state is independent of the pseudowire state. This mode provides faster switchover time when a platform does not support pseudowire status functionality, but extra flooding and multicast traffic will be dropped on the PE with standby attachment circuits. However, if the attachment circuit is down, all pseudowires also go down. See the figure below.

Steps for Configuring Redundancy for VPLS

For more information on VPLS, see Configuring Virtual Private LAN Services.

Perform the following task to configure redundancy for VPLS.

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 **l2 vfi** *name* **manual**

Example:

```
Router(config)# l2 vfi vfi1 manual
```

Establishes a Layer 2 VFI between two separate networks and enters VFI configuration mode.

Step 4 **vpn id** *vpn-id*

Example:

```
Router(config-vfi)# vpn id 100
```

Sets or updates a Virtual Private Network (VPN) ID on a VPN routing and forwarding (VRF) instance.

Step 5 **bridge-domain** *bd-id*

Example:

```
Router(config-vfi)# bridge-domain 100
```

Binds a service instance to a bridge domain instance.

Step 6 **status decoupled**

Example:

```
Router(config-vfi)# status decoupled
```

(Optional) Enables decoupled mode. The state of the attachment circuits on the user-facing Provider Edge (uPE) is decoupled from the state of the pseudowires. The mLACP controls the state of the attachment circuits.

Step 7 **neighbor** *neighbor ip-address vc-id* {**encapsulation mpls** | **pw-class** *pw-class-name*}

Example:

```
Router(config-vfi)# neighbor 10.1.1.1 50 encapsulation mpls
```

Specifies the routers that should form a VFI connection.

- Repeat this command for each neighbor.

Step 8 **exit**

Example:

```
Router(config-vfi)# exit
```

Exits VFI configuration mode and returns to global configuration mode.

Step 9 **interface port-channel** *port-channel- number*

Example:

```
Router(config)# interface port-channel1
```

Configures the port channel and enters interface configuration mode.

Step 10 **no ip address**

Example:

```
Router(config-if)# no ip address
```

Specifies that the VLAN interface does not have an IP address assigned to it.

Step 11 **lacp fast-switchover**

Example:

```
Router(config-if)# lacp fast-switchover
```

Enables LACP 1-to-1 link redundancy.

Step 12 **lacp max-bundle** *max-bundles*

Example:

```
Router(config-if)# lacp max-bundle 2
```

Configures the max-bundle links that are connected to the PoA. The value of the *max-bundles*argument should not be less than the total number of links in the LAG that are connected to the PoA.

- Determines whether the redundancy group is under DHD control, PoA control, or both.
- Range is 1 to 8. Default value is 8.

Step 13 **mlacp interchassis group** *group-id*

Example:

```
Router(config-red)# mlacp interchassis group 230
```

Specifies that the port channel is an mLACP port-channel.

- The *group-id* should match the configured redundancy group.

Step 14 **interface port-channel** *port-channel- number*

Example:

```
Router(config)# interface port-channel1
```

Configures the port channel and enters interface configuration mode.

Step 15 **service instance** *id* **ethernet** [*evc-name*]

Example:

```
Router(config-if)# service instance 1 ethernet
```

Configures an Ethernet service instance and enters Ethernet service configuration mode.

Step 16 **encapsulation dot1q** *vlan-id* [**,** *vlan-id*[**-** *vlan-id*]]

Example:

```
Router(config-if-srv)# encapsulation dot1q 100
```

Enables IEEE 802.1Q encapsulation of traffic on a specified subinterface in a VLAN.

Step 17 **bridge-domain** *bridge-id* [**split-horizon** [**group** *group-id*]]

Example:

```
Router(config-if-srv)# bridge-domain 200
```

Configures the bridge domain. Binds the service instance to a bridge domain instance where *domain-number* is the identifier for the bridge domain instance.

Step 18 **exit**

Example:

```
Router(config-if-srv)# exit
```

Exits service instance configuration mode.

Step 19 **end**

Example:

```
Router(config-if)# end
```

Returns the CLI to privileged EXEC mode.

Configuring Hierarchical VPLS

Perform this task to configure Hierarchical VPLS (H-VPLS).

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 **pseudowire-class** *pw-class-name*

Example:

```
Router(config)# pseudowire-class ether-pw
```

Specifies the name of a Layer 2 pseudowire class and enters pseudowire class configuration mode.

Step 4 **encapsulation mpls**

Example:

```
Router(config-pw-class)# encapsulation mpls
```

Specifies that MPLS is used as the data encapsulation method for tunneling Layer 2 traffic over the pseudowire.

Step 5 **status peer topology dual-homed**

Example:

```
Router(config-pw-class)# status peer topology dual-homed
```

Enables the reflection of the attachment circuit status onto both the primary and secondary pseudowires. This configuration is necessary if the peer PEs are connected to a dual-homed device.

Step 6 **exit**

Example:

```
Router(config-pw-class)# exit
```

Exits pseudowire class configuration mode and returns to global configuration mode.

Step 7 **interface port-channel** *port-channel- number*

Example:

```
Router(config)# interface port-channel1
```

Configures the port channel and enters interface configuration mode.

Step 8 **no ip address**

Example:

```
Router(config-if)# no ip address
```

Specifies that the VLAN interface does not have an IP address assigned to it.

Step 9 **lacp fast-switchover**

Example:

```
Router(config-if)# lacp fast-switchover
```

Enables LACP 1-to-1 link redundancy.

Step 10 **lacp max-bundle** *max-bundles*

Example:

```
Router(config-if)# lacp max-bundle 4
```

Configures the max-bundle links that are connected to the PoA. The value of the *max-bundles*argument should not be less than the total number of links in the LAG that are connected to the PoA.

- Determines whether the redundancy group is under DHD control, PoA control, or both.
- Range is 1 to 8. Default value is 8.

Step 11 **mlacp interchassis group** *group-id*

Example:

```
Router(config-red)# mlacp interchassis group 230
```

Specifies that the port channel is an mLACP port channel.

- The *group-id* should match the configured redundancy group.

Step 12 **exit**

Example:

```
Router(config-red)# exit
```

Exits redundancy configuration mode.

Step 13 **interface port-channel** *port-channel- number*

Example:

```
Router(config)# interface port-channel1
```

Configures the port channel and enters interface configuration mode.

Step 14 **service instance** *id* **ethernet** [*evc-name*]

Example:

```
Router(config-if)# service instance 1 ethernet
```

Configures an Ethernet service instance and enters Ethernet service configuration mode.

Step 15 **encapsulation dot1q** *vlan-id* [**,** *vlan-id*[**-** *vlan-id*]]

Example:

```
Router(config-if-srv)# encapsulation dot1q 100
```

Enables IEEE 802.1Q encapsulation of traffic on a specified subinterface in a VLAN.

Step 16 **xconnect** *peer-ip-address vc-id* {**encapsulation mpls** | **pw-class** *pw-class-name*} [**pw-class** *pw-class-name*] [**sequencing** {**transmit** | **receive** | **both**}]

Example:

```
Router(config-if)# xconnect 10.0.3.201 123 pw-class vlan-xconnect
```

Binds an attachment circuit to a pseudowire, and configures an Any Transport over MPLS (AToM) static pseudowire.

Step 17 **backup peer** *peer-router-ip-addr vcid* [**pw-class** *pw-class-name*] [**priority** *value*]

Example:

```
Router(config-if)# backup peer 10.1.1.1 123 pw-class ether-pw
```

Specifies a redundant peer for a pseudowire virtual circuit.

Step 18 **end**

Example:

```
Router(config-if)# end
```

Returns the CLI to privileged EXEC mode.

Troubleshooting mLACP

Debugging mLACP

Use these **debug** commands for general mLACP troubleshooting.

Step 1 **enable**

Example:

```
Router> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

Step 2 **debug redundancy interchassis** {**all** | **application** | **error** | **event** | **monitor**}

Example:

```
Router# debug redundancy interchassis all
```

- Enables debugging of the interchassis redundancy manager.

Step 3 **debug mpls ldp iccp**

Example:

```
Router# debug mpls ldp iccp
```

- Enables debugging of the InterChassis Control Protocol (ICCP).

Step 4 **debug lacp** [**all** | **event**| **fsm**| **misc**| **multi-chassis** [**all** | **database** | **lacp-mgr** | **redundancy-group** | **user-interface**] | **packet**]

Example:

```
Router# debug lacp multi-chassis all
```

Enables debugging of LACP activity.

- This command is run on the switch processor.

Step 5 **debug lacp etherchannel**

Example:

```
Router# debug lacp etherchannel
```

Enables debugging for etherchannel component.

Debugging mLACP on an Attachment Circuit or EVC

Use these **debug** commands for troubleshooting mLACP on an attachment circuit or on an EVC.

Step 1 **enable**

Example:

```
Router> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

Step 2 **debug acircuit** {**checkpoint** | **error** | **event**}

Example:

```
Router# debug acircuit event
```

Displays checkpoints, errors, and events that occur on the attachment circuits between the PE and CE routers.

Step 3 **debug ethernet service** {**all** | **api** | **error** | **evc** [*evc-id*] | **ha** | **instance** [**id** *id* | **interface** *type number* | **qos**] | **interface** *type number* | **microblock** | **oam-mgr**}

Example:

```
Router# debug ethernet service all
```

Enables debugging of Ethernet customer service instances.

Debugging mLACP on AToM Pseudowires

Use the **debug mpls l2transport vc** command for troubleshooting mLACP on AToM pseudowires.

Step 1 **enable**

Example:

```
Router> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

Step 2 **debug mpls l2transport vc** {**event** | **fsm** | **ldp** | **sss** | **status** {**event** | **fsm**}}

Example:

```
Router# debug mpls l2transport status event
```

Displays information about the status of AToM virtual circuits (VCs).

Debugging Cross-Connect Redundancy Manager and Session Setup

Use the following **debug**commands to troubleshoot cross-connect, redundancy manager, and session setup.

Step 1 **enable**

Example:

```
Router> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

Step 2 **debug sss error**

Example:

```
Router# debug sss error
```

Displays diagnostic information about errors that may occur during a subscriber service switch (SSS) call setup.

Step 3 **debug sss events**

Example:

```
Router# debug sss event
```

Displays diagnostic information about SSS call setup events.

Step 4 **debug xconnect** {**error** | **event**}

Example:

```
Router# debug xconnect event
```

Displays errors or events related to a cross-connect configuration.

Debugging VFI

Use the **debug vfi**command for troubleshooting a VFI.

Step 1 **enable**

Example:

```
Router> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

Step 2 **debug vfi** {**checkpoint** | **error** | **event** | **fsm** {**error** | **event**}}

Example:

```
Router# debug vfi checkpoint
```

Displays checkpoint information about a VFI.

Debugging the Segment Switching Manager (Switching Setup)

Use the **debug ssm**command for troubleshooting a segment switching manager (SSM).

Step 1 **enable**

Example:

```
Router> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

Step 2 **debug ssm** {**cm errors** | **cm events** | **fhm errors** | **fhm events** | **sm errors** | **sm events** | **sm counters** | **xdr**}

Example:

```
Router# debug ssm cm events
```

Displays diagnostic information about the SSM for switched Layer 2 segments.

Debugging High Availability Features in mLACP

Use the following **debug**commands for troubleshooting High Availability features in mLACP.

Step 1 **enable**

Example:

```
Router> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

Step 2 **debug mpls l2transport checkpoint**

Example:

```
Router# debug mpls l2transport checkpoint
```

Enables the display of AToM events when AToM is configured for nonstop forwarding/stateful switchover (NSF/SSO) and Graceful Restart.

Step 3 **debug acircuit checkpoint**

Example:

```
Router# debug acircuit checkpoint
```

Enables the display of attachment circuit events when AToM is configured for NSF/SSO and Graceful Restart.

Step 4 **debug vfi checkpoint**

Example:

```
Router# debug vfi checkpoint
```

Enables the display of VFI events when AToM is configured for NSF/SSO and Graceful Restart.

Configuration Examples for mLACP

Example Configuring mLACP on L3VPN

The following configuration is for mLACP on L3VPN:

```
vrf definition vpn_1
 rd 100:1
 ! address-family ipv4
  route-target export 100:1
  route-target import 100:1
 exit-address-family
 ! address-family ipv6
  route-target export 100:1
  route-target import 100:1
 exit-address-family
!
port-channel mc-lag   <<<<<<<<<cli to enable this feature
!
mpls label protocol ldp
mpls ldp nsr
mpls ldp graceful-restart
!
redundancy
 mode sso
 interchassis group 100
  monitor peer bfd
  member ip 2.2.2.2
  backbone interface GigabitEthernet0/0/7
  mlacp system-mac 2222.2222.2222
  mlacp system-priority 2000
  mlacp node-id 2
bfd-template single-hop BFD_IPv4
 interval min-tx 50 min-rx 50 multiplier 3
!
bfd-template single-hop TEST
 interval min-tx 50 min-rx 50 multiplier 3
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface Port-channel1
lacp fast-switchover
 lacp max-bundle 3
 mlacp lag-priority 32768
 mlacp interchassis group 100
 service instance 101 ethernet
  encapsulation dot1q 101
  rewrite ingress tag pop 1 symmetric
  bridge-domain 101
 !  service instance 102 ethernet
```

```
  encapsulation dot1q 102
  rewrite ingress tag pop 1 symmetric
  bridge-domain 102
 !
service instance 3999 ethernet
  encapsulation untagged
  l2protocol peer lacp
  bridge-domain 3999
 !
 interface GigabitEthernet0/0/3
 no ip address
 carrier-delay msec 25
 negotiation auto
 lacp rate fast
 channel-group 1 mode active
!

interface GigabitEthernet0/0/5 --> ICCP link between PoA1 & PoA2
 ip address 11.11.11.2 255.255.255.0
 load-interval 30
 negotiation auto
 mpls ip
 mpls label protocol ldp
 bfd template BFD_IPv4
!
interface GigabitEthernet0/0/7 --> Core intf towards PE3
 ip address 12.12.12.2 255.255.255.0
 load-interval 30
 negotiation auto
 mpls ip
 mpls label protocol ldp
!
interface BDI101
 vrf forwarding vpn_1
 ip address 121.1.1.1 255.255.255.0
 ip ospf bfd
 ip ospf 10 area 0
  bfd template TEST
!
interface BDI102
 vrf forwarding vpn_1
 ip address 122.1.1.1 255.255.255.0
  !
router ospf 100
 router-id 1.1.1.1
 nsr
 nsf cisco
 fast-reroute per-prefix enable prefix-priority high
 fast-reroute per-prefix remote-lfa tunnel mpls-ldp
 network 1.1.1.0 0.0.0.255 area 0
 network 11.11.11.0 0.0.0.255 area 0
 network 12.12.12.0 0.0.0.255 area 0
 network 13.13.13.0 0.0.0.255 area 0
 network 121.1.1.0 0.0.0.255 area 0
 network 0.0.0.0 255.255.255.255 area 0
 bfd all-interfaces
 mpls ldp autoconfig
!
router bgp 100
 bgp log-neighbor-changes
 bgp graceful-restart
 neighbor 4.4.4.4 remote-as 100
 neighbor 4.4.4.4 ha-mode sso
 neighbor 4.4.4.4 update-source Loopback0
```

```
 neighbor 121.1.1.2 remote-as 101
 neighbor 121.1.1.2 ha-mode sso
 neighbor 121.1.1.2 fall-over bfd check-control-plane-failure
 !
 address-family ipv4
  neighbor 4.4.4.4 activate
  neighbor 121.1.1.2 activate
 exit-address-family
 !
 address-family vpnv4
  neighbor 4.4.4.4 activate
  neighbor 4.4.4.4 send-community extended
 exit-address-family
 !
 address-family ipv4 vrf vpn_1
  redistribute connected
  redistribute static
  neighbor 121.1.1.2 remote-as 101
  neighbor 121.1.1.2 activate
  neighbor 121.1.1.2 as-override
 exit-address-family
!
ip route vrf vpn_1 131.1.1.0 255.255.255.0 121.1.1.2
ip route vrf vpn_1 132.1.1.0 255.255.255.0 121.1.1.2
!
mpls ldp router-id Loopback0 force
```

Example Configuring NSF and NSR

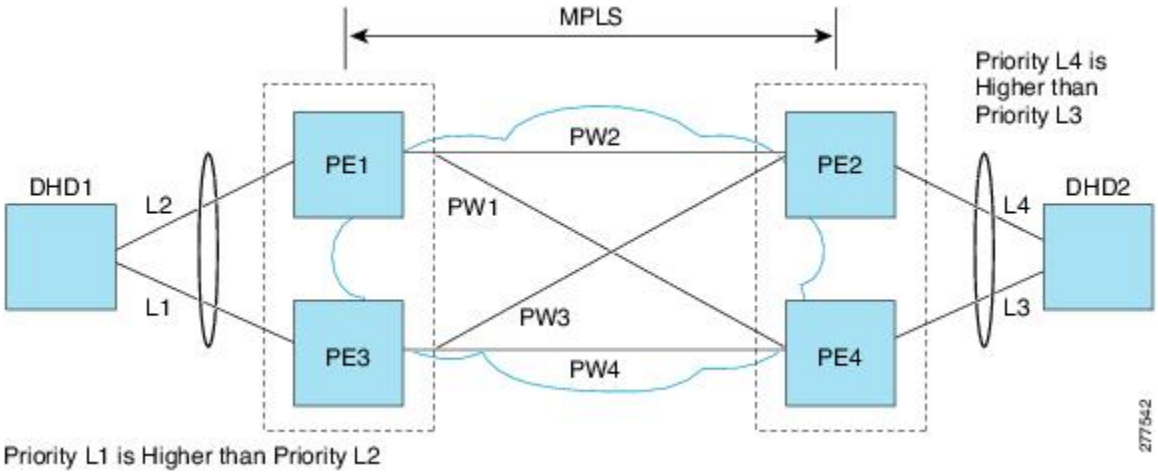
The following configuration is for NSF (Non-stop Forwarding) and NSR (Non-stop Routing):

```
mpls ldp nsr
mpls ldp graceful-restart --> Enabling NSF
router ospf < >
 nsr
 nsf cisco
router bgp <>
bgp ha-mode sso --> Enabling NSR for BGP
 bgp graceful-restart --> Enabling NSF
neighbor 1.1.1.1 ha-mode sso
address-family ipv4 vrf vpn_1
Neighbor < > ha-mode sso
```

Example Configuring VPWS

Two sample configurations for VPWS follow: one example for an active PoA and the other for a standby PoA.

The figure below shows a sample topology for a VPWS configuration.



Active PoA for VPWS

The following VPWS sample configuration is for an active PoA:

```
mpls ldp router-id Loopback0 force
mpls ldp graceful-restart
mpls label protocol ldp
!
bfd-template single-hop BFD_IPv4
interval min-tx 50 min-rx 50 multiplier 3
!
redundancy
mode sso
interchassis group 100
  monitor peer bfd
  member ip 2.2.2.2
  backbone interface GigabitEthernet0/1/4
  backbone interface GigabitEthernet0/5/0
  mlacp system-priority 1000
  mlacp node-id 1
!
pseudowire-class mlacp
encapsulation mpls
status peer topology dual-homed
!
interface Loopback0
ip address 1.1.1.1 255.255.255.255
!
interface Port-channel1
no ip address
load-interval 30
negotiation auto
lacp failover non-revertive
lacp fast-switchover
lacp max-bundle 4
lacp min-bundle 2
mlacp lag-priority 2
mlacp interchassis group 100
service instance 2 ethernet
  encapsulation dot1q 2
  rewrite ingress tag pop 1 symmetric
  xconnect 3.3.3.3 2 encapsulation mpls pw-class mlacp
   backup peer 4.4.4.4 2 pw-class mlacp
```

```
service instance 3999 ethernet
  encapsulation untagged
  l2protocol peer lacp
  bridge-domain 3999

!
interface GigabitEthernet0/1/0
no ip address
load-interval 30
carrier-delay msec 25
no negotiation auto
lacp rate fast
channel-group 1 mode active
end
!
interface TenGigabitEthernet0/2/0
ip address 11.11.11.2 255.255.255.0
load-interval 30
mpls ip
mpls label protocol ldp
bfd template BFD_IPv4
end
```

Standby PoA for VPWS

The following VPWS sample configuration is for a standby PoA:

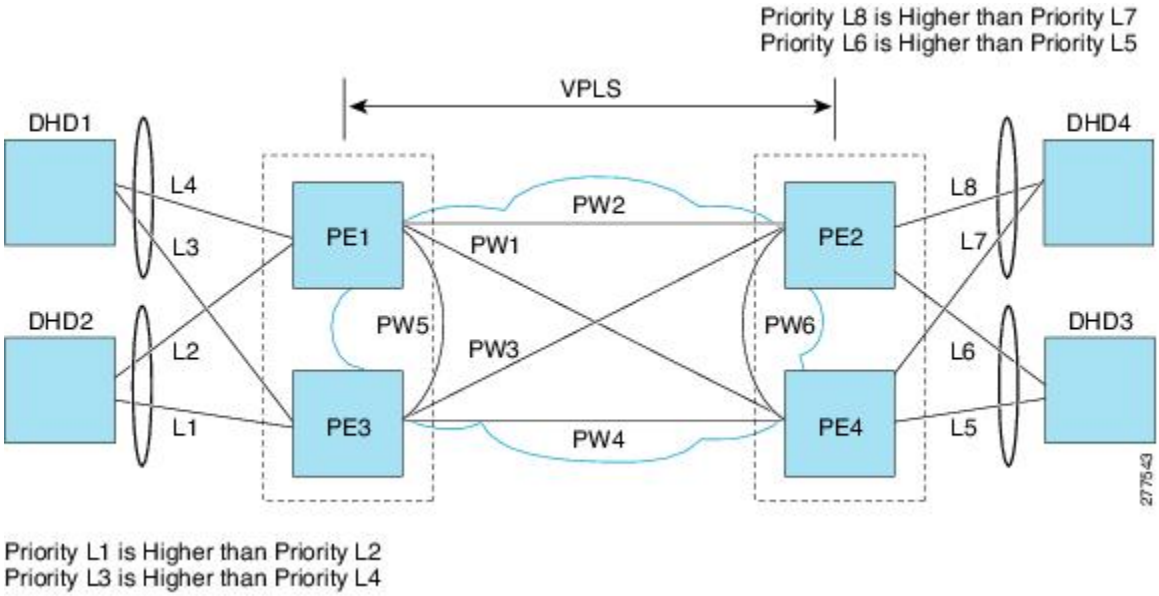
```
mpls ldp router-id Loopback0 forc
mpls ldp graceful-restart
mpls label protocol ldp
!
bfd-template single-hop BFD_IPv4
interval min-tx 50 min-rx 50 multiplier 3
!
redundancy
mode sso
interchassis group 100
  monitor peer bfd
  member ip 1.1.1.1
  backbone interface GigabitEthernet0/6/0
  backbone interface GigabitEthernet0/2/0
  mlacp system-priority 2000
  mlacp node-id 2
!
pseudowire-class mlacp
encapsulation mpls
status peer topology dual-homed
!
interface Loopback0
ip address 2.2.2.2 255.255.255.255
!
interface Port-channel1
no ip address
load-interval 30
no negotiation auto
lacp failover non-revertive
lacp fast-switchover
lacp max-bundle 4
lacp min-bundle 2
mlacp lag-priority 32768
mlacp interchassis group 100
service instance 2 ethernet
  encapsulation dot1q 2
```

```
  rewrite ingress tag pop 1 symmetric
  xconnect 3.3.3.3 2 encapsulation mpls pw-class mlacp
   backup peer 4.4.4.4 2 pw-class mlacp

!
interface GigabitEthernet0/6/4
no ip address
load-interval 30
carrier-delay msec 25
no negotiation auto
lacp rate fast
channel-group 1 mode active
!
interface TenGigabitEthernet0/3/0
ip address 11.11.11.1 255.255.255.0
load-interval 30
mpls ip
mpls label protocol ldp
bfd template BFD_IPv4
```

Example Configuring VPLS

Two sample configurations for VPLS follow: one example for an active PoA and the other for a standby PoA.

The figure below shows a sample topology for a VPLS configuration.



Active PoA for VPLS

The following VPLS sample configuration is for an active PoA:

```
mpls ldp router-id Loopback0 force
mpls ldp graceful-restart
mpls label protocol ldp
!
bfd-template single-hop BFD_IPv4
interval min-tx 50 min-rx 50 multiplier 3
!
```

```
redundancy
mode sso
interchassis group 100
  monitor peer bfd
  member ip 2.2.2.2
  backbone interface GigabitEthernet0/1/4
  backbone interface GigabitEthernet0/5/0
  mlacp system-priority 1000
  mlacp node-id 1
!
l2 vfi VPLS_200 manual
vpn id 200
bridge-domain 200
neighbor 3.3.3.3 encapsulation mpls
neighbor 4.4.4.4 encapsulation mpls
neighbor 2.2.2.2 encapsulation mpls
!
interface Loopback0
ip address 1.1.1.1 255.255.255.255
!
interface Port-channel1
no ip address
lacp fast-switchover
lacp max-bundle 4
lacp min-bundle 2
mlacp interchassis group 100
service instance 1 ethernet
  encapsulation dot1q 100
  rewrite ingress tag pop 1 symmetric
  bridge-domain 200
  service instance 3999 ethernet
  encapsulation untagged
  l2protocol peer lacp
  bridge-domain 3999

!
interface GigabitEthernet0/1/0
no ip address
load-interval 30
carrier-delay msec 25
no negotiation auto
lacp rate fast
channel-group 1 mode active
end
!
interface TenGigabitEthernet0/2/0
ip address 11.11.11.2 255.255.255.0
load-interval 30
mpls ip
mpls label protocol ldp
bfd template BFD_IPv4
end
```

Standby PoA for VPLS

The following VPLS sample configuration is for a standby PoA:

```
mpls ldp router-id Loopback0 force
mpls ldp graceful-restart
mpls label protocol ldp
!
bfd-template single-hop BFD_IPv4
```

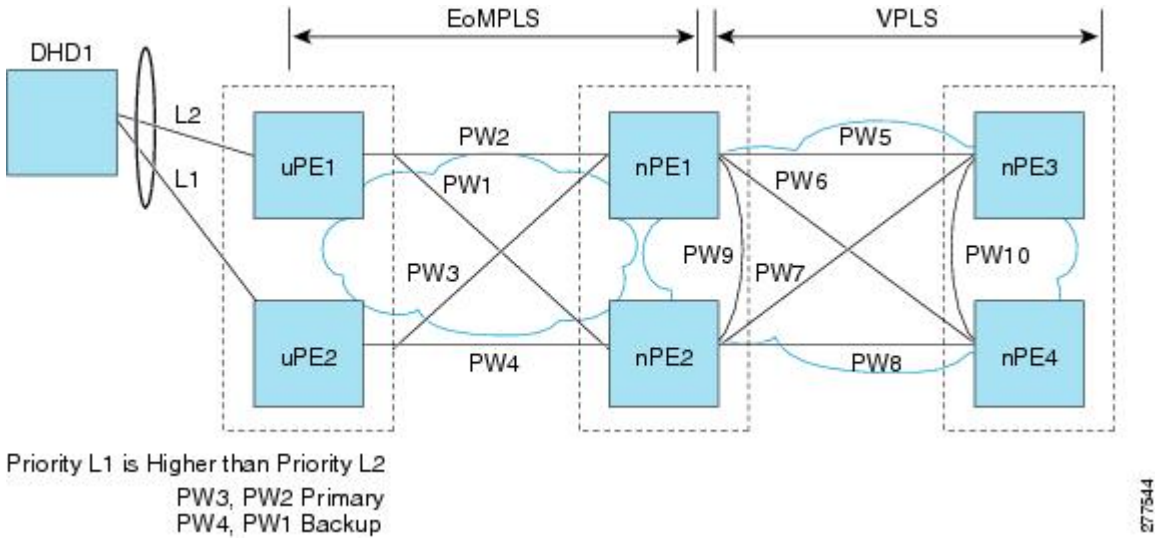
```
interval min-tx 50 min-rx 50 multiplier 3
!
redundancy
mode sso
interchassis group 100
  monitor peer bfd
  member ip 1.1.1.1
  backbone interface GigabitEthernet0/6/0
  backbone interface GigabitEthernet0/2/0
  mlacp system-priority 2000
  mlacp node-id 2
!
l2 vfi VPLS_200 manual
vpn id 200
bridge-domain 200
neighbor 3.3.3.3 encapsulation mpls
neighbor 4.4.4.4 encapsulation mpls
neighbor 1.1.1.1 encapsulation mpls
!
interface Loopback0
ip address 2.2.2.2 255.255.255.255
!
interface Port-channel1
no ip address
lacp fast-switchover
lacp max-bundle 4
lacp min-bundle 2
mlacp lag-priority 40000
mlacp interchassis group 1
service instance 1 ethernet
  encapsulation dot1q 100
  rewrite ingress tag pop 1 symmetric
  bridge-domain 200
  service instance 3999 ethernet
  encapsulation untagged
  l2protocol peer lacp
  bridge-domain 3999

!
interface GigabitEthernet0/6/4
no ip address
load-interval 30
carrier-delay msec 25
no negotiation auto
lacp rate fast
channel-group 1 mode active
!
interface TenGigabitEthernet0/3/0
ip address 11.11.11.1 255.255.255.0
load-interval 30
mpls ip
mpls label protocol ldp
bfd template BFD_IPv4
```

F or protocol based CLIs for VPLS configuration, see L2VPN Protocol-Based CLIs.

Example Configuring H-VPLS

Two sample configurations for H-VPLS follow: one example for an active PoA and the other for a standby PoA.

The figure below shows a sample topology for a H-VPLS configuration.



Active PoA for H-VPLS

The following H-VPLS sample configuration is for an active PoA:

```
mpls ldp router-id Loopback0 force
mpls ldp graceful-restart
mpls label protocol ldp
!
bfd-template single-hop BFD_IPv4
interval min-tx 50 min-rx 50 multiplier 3
!
redundancy
mode sso
interchassis group 100
  monitor peer bfd
  member ip 2.2.2.2
  backbone interface GigabitEthernet0/1/4
  backbone interface GigabitEthernet0/5/0
  mlacp system-priority 1000
  mlacp node-id 1
!
pseudowire-class mlacp
encapsulation mpls
status peer topology dual-homed
!
interface Loopback0
ip address 1.1.1.1 255.255.255.255
!
interface Port-channel1
no ip address
load-interval 30
negotiation auto
lacp failover non-revertive
lacp fast-switchover
lacp max-bundle 4
lacp min-bundle 2
mlacp lag-priority 2
mlacp interchassis group 100
service instance 2 ethernet
  encapsulation dot1q 2
  rewrite ingress tag pop 1 symmetric
```

```
  xconnect 3.3.3.3 2 encapsulation mpls pw-class mlacp
   backup peer 4.4.4.4 2 pw-class mlacp
service instance 3999 ethernet
  encapsulation untagged
  l2protocol peer lacp
  bridge-domain 3999

!
interface GigabitEthernet0/1/0
no ip address
load-interval 30
carrier-delay msec 25
no negotiation auto
lacp rate fast
channel-group 1 mode active
end
!
interface TenGigabitEthernet0/2/0
ip address 11.11.11.2 255.255.255.0
load-interval 30
mpls ip
mpls label protocol ldp
bfd template BFD_IPv4
end
```

Standby PoA for H-VPLS

The following H-VPLS sample configuration is for a standby PoA:

```
mpls ldp router-id Loopback0 forc
mpls ldp graceful-restart
mpls label protocol ldp
!
bfd-template single-hop BFD_IPv4
interval min-tx 50 min-rx 50 multiplier 3
!
redundancy
mode sso
interchassis group 100
  monitor peer bfd
  member ip 1.1.1.1
  backbone interface GigabitEthernet0/6/0
  backbone interface GigabitEthernet0/2/0
  mlacp system-priority 2000
  mlacp node-id 2
!
pseudowire-class mlacp
encapsulation mpls
status peer topology dual-homed
!
interface Loopback0
ip address 2.2.2.2 255.255.255.255
!
interface Port-channel1
no ip address
load-interval 30
no negotiation auto
lacp failover non-revertive
lacp fast-switchover
lacp max-bundle 4
lacp min-bundle 2
mlacp lag-priority 32768
mlacp interchassis group 100
```

```
service instance 2 ethernet
  encapsulation dot1q 2
  rewrite ingress tag pop 1 symmetric
  xconnect 3.3.3.3 2 encapsulation mpls pw-class mlacp
   backup peer 4.4.4.4 2 pw-class mlacp

!
interface GigabitEthernet0/6/4
no ip address
load-interval 30
carrier-delay msec 25
no negotiation auto
lacp rate fast
channel-group 1 mode active
!
interface TenGigabitEthernet0/3/0
ip address 11.11.11.1 255.255.255.0
load-interval 30
mpls ip
mpls label protocol ldp
bfd template BFD_IPv4
```

Example Verifying VPWS on an Active PoA

The following **show** commands can be used to display statistics and configuration parameters to verify the operation of the mLACP feature on an active PoA:

show lacp multichassis group

Use the **show lacp multichassis group** command to display the interchassis redundancy group value and the operational LACP parameters.

```
Router# show lacp multichassis group 100
Interchassis Redundancy Group 100

Operational LACP Parameters:
RG State: Synchronized
System-Id: 1000.7426.acf6.c000
ICCP Version: 0
Backbone Uplink Status: Connected
Local Configuration:
Node-id: 3
System-Id: 1000.7426.acf6.c000

Peer Information:
State: Up
Node-id: 4
System-Id: 2000.f078.166e.7a00
ICCP Version: 0

State Flags: Active - A
Standby - S
Down - D
AdminDown - AD
Standby Reverting - SR
Unknown - U

mLACP Channel-groups
Channel State Priority Active Links Inactive Links
Group Local/Peer Local/Peer Local/Peer Local/Peer
```

```
1 A/S 32773/32774 4/4 0/0
```

show lacp multichassis port-channel

Use the **show lacp multichassis port-channel** command to display the interface port-channel value channel group, LAG state, priority, inactive links peer configuration, and standby links.

```
Router# show lacp multichassis port-channel1
Interface Port-channel1
Local Configuration:
Address: 7426.acf6.c0cb
Channel Group: 1
State: Active
LAG State: Up
Priority: 32773
Inactive Links: 0
Total Active Links: 4
Bundled: 4
Selected: 4
Standby: 0
Unselected: 0

Peer Configuration:
Interface: Port-channel1
Address: f078.166e.7a41
Channel Group: 1
State: Standby
LAG State: Up
Priority: 32774
Inactive Links: 0
Total Active Links: 4
Bundled: 0
Selected: 0
Standby: 4
Unselected: 0
```

show mpls ldp iccp

Use the **show mpls ldp iccp** command to display the LDP session and ICCP state information.

```
Router# show mpls ldp iccp

ICPM RGID Table
iccp:
rg_id: 100, peer addr: 2.2.2.2
ldp_session 0x2, client_id 0
iccp state: ICPM_ICCP_CONNECTED
app type: MLACP
app state: ICPM_APP_CONNECTED, ptcl ver: 0
ICPM RGID Table total ICCP sessions: 1
ICPM LDP Session Table
iccp:
rg_id: 100, peer addr: 2.2.2.2
ldp_session 0x2, client_id 0
iccp state: ICPM_ICCP_CONNECTED
app type: MLACP
app state: ICPM_APP_CONNECTED, ptcl ver: 0
ICPM LDP Session Table total ICCP sessions: 1

ICPM peer table:
```

```
peer:
peer addr: 2.2.2.2, ldp session: 0x2
Discovery handle: 0x450595EC
Num ICCP Sessions: 1
ATS event occurred: TRUE
```

show mpls l2transport

Use the **show mpls l2transport** command to display the local interface and session details, destination address, and status.

```
Router# show mpls l2transport vc 2
Local intf     Local circuit              Dest address    VC ID      Status
-------------  -------------------------- --------------- ---------- ----------
Po1            Eth VLAN 2                 172.2.2.2       2          UP
Po1            Eth VLAN 2                 172.4.4.4       2          STANDBY
```

show etherchannel summary

Use the **show etherchannel summary** command to display the status and identity of the mLACP member links.

```
Router# show etherchannel summary
Flags:  D - down        P/bndl - bundled in port-channel
        I - stand-alone s/susp - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port

Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1 Po1(RU) LACP Gi0/0/1(bndl-act) Gi0/0/2(bndl-act) Gi0/0/3(bndl-act) Gi0/0/4(bndl-act)

RU - L3 port-channel UP State
SU - L2 port-channel UP state
P/bndl -  Bundled
S/susp  - Suspended
```

show lacp internal

Use the **show lacp internal**command to display the device, port, and member- link information.

```
Router# 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 1
                            LACP port     Admin     Oper    Port        Port
Port      Flags   State     Priority      Key       Key     Number      State
```

```
Gi0/0/1   FA      bndl-act  2             0x1       0x1     0xB002      0x3D
Gi0/0/2   FA      bndl-act  2             0x1       0x1     0xB003      0x3D
Gi0/0/3   FA      bndl-act  2             0x1       0x1     0xB004      0x3D
Gi0/0/4   FA      bndl-act  2             0x1       0x1     0xB005      0x3D

Peer (ASR903-PE4) mLACP member links

Gi0/0/1   FA      bndl-sby  32768         0x1       0x1     0xC002      0xD
Gi0/0/2   FA      bndl-sby  32768         0x1       0x1     0xC003      0xD
Gi0/0/3   FA      bndl-sby  32768         0x1       0x1     0xC004      0xD
Gi0/0/0   FA      bndl-sby  32768         0x1       0x1     0xC001      0xD
```

Example Verifying VPWS on a Standby PoA

The following **show** commands can be used to display statistics and configuration parameters to verify the operation of the mLACP feature on a standby PoA:

show lacp multichassis group

Use the **show lacp multichassis group** command to display the LACP parameters, local configuration, status of the backbone uplink, peer information, node ID, channel, state, priority active, and inactive links.

```
Router# show lacp multichassis group 100
Interchassis Redundancy Group 100

Operational LACP Parameters:
RG State: Synchronized
System-Id: 1000.7426.acf6.c000
ICCP Version: 0
Backbone Uplink Status: Connected
Local Configuration:
Node-id: 4
System-Id: 2000.f078.166e.7a00

Peer Information:
State: Up
Node-id: 3
System-Id: 1000.7426.acf6.c000
ICCP Version: 0

State Flags: Active - A
Standby - S
Down - D
AdminDown - AD
Standby Reverting - SR
Unknown - U

mLACP Channel-groups
Channel      State     Priority       Active Links    Inactive Links
 Group    Local/Peer  Local/Peer       Local/Peer      Local/Peer
   1          S/A     32774/32773         4/4            0/0
```

show lacp multichassis portchannel

Use the **show lacp multichassis portchannel** command to display the interface port-channel value channel group, LAG state, priority, inactive links peer configuration, and standby links.

```
Router# show lacp multichassis port-channel1
```

```
Interface Port-channel1
Local Configuration:
Address: f078.166e.7a41
Channel Group: 1
State: Standby
LAG State: Up
Priority: 32774
Inactive Links: 0
Total Active Links: 4
Bundled: 0
Selected: 0
Standby: 4
Unselected: 0

Peer Configuration:
Interface: Port-channel1
Address: 7426.acf6.c0cb
Channel Group: 1
State: Active
LAG State: Up
Priority: 32773
Inactive Links: 0
Total Active Links: 4
Bundled: 4
Selected: 4
Standby: 0
Unselected: 0
```

show mpls ldp iccp

Use the **show mpls ldp iccp**command to display the LDP session and ICCP state information.

```
Router# show mpls ldp iccp
ICPM RGID Table
iccp:
rg_id: 100, peer addr: 1.1.1.1
ldp_session 0x2, client_id 0
iccp state: ICPM_ICCP_CONNECTED
app type: MLACP
app state: ICPM_APP_CONNECTED, ptcl ver: 0
ICPM RGID Table total ICCP sessions: 1
ICPM LDP Session Table
iccp:
rg_id: 100, peer addr: 1.1.1.1
ldp_session 0x2, client_id 0
iccp state: ICPM_ICCP_CONNECTED
app type: MLACP
app state: ICPM_APP_CONNECTED, ptcl ver: 0
ICPM LDP Session Table total ICCP sessions: 1

ICPM peer table:
peer:
peer addr: 1.1.1.1, ldp session: 0x2
Discovery handle: 0x44AFB42C
Num ICCP Sessions: 1
ATS event occurred: TRUE
```

show mpls l2transport

Use the **show mpls l2transport** command to display the local interface and session details, destination address, and status.

```
Router# show mpls l2transport vc 2
Local intf     Local circuit              Dest address    VC ID      Status
-------------  -------------------------- --------------- ---------- ----------
Po1            Eth VLAN 2                 172.2.2.2       2          STANDBY
Po1            Eth VLAN 2                 172.4.4.4       2          STANDBY
```

show etherchannel summary

Use the **show etherchannel summary** command to display the status and identity of the mLACP member links.

```
Router# show etherchannel summary
Flags:  D - down        P/bndl - bundled in port-channel
        I - stand-alone s/susp - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1 Po1(RU) LACP Gi0/0/0(bndl-sby) Gi0/0/1(bndl-sby) Gi0/0/2(bndl-sby) Gi0/0/3(bndl-sby)

RU - L3 port-channel UP State
SU - L2 port-channel UP state
P/bndl -  Bundled
S/susp  - Suspended
```

show lacp internal

Use the **show lacp internal** command to display the device, port, and member-link information.

```
Router# 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 1
LACP port Admin Oper Port Port
Port    Flags   State   Priority    Key   Key  Number  State
Gi0/0/0  FA    bndl-sby  32774      0x1   0x1  0xC001  0xF
Gi0/0/1  FA    bndl-sby  32774      0x1   0x1  0xC002  0xF
Gi0/0/2  FA    bndl-sby  32774      0x1   0x1  0xC003  0xF
Gi0/0/3  FA    bndl-sby  32774      0x1   0x1  0xC004  0xF

Peer (ASR903-PE3) mLACP member links

Gi0/0/2 FA bndl-act 32773 0x1 0x1 0xB003 0x3F
Gi0/0/3 FA bndl-act 32773 0x1 0x1 0xB004 0x3F
Gi0/0/4 FA bndl-act 32773 0x1 0x1 0xB005 0x3F
Gi0/0/1 FA bndl-act 32773 0x1 0x1 0xB002 0x3F
```

Example Verifying VPLS on an Active PoA

The following **show** commands can be used to display statistics and configuration parameters to verify the operation of the mLACP feature on an active PoA:

show lacp multichassis group

Use the **show lacp multichassis group** command to display the LACP parameters, local configuration, status of the backbone uplink, peer information, node ID, channel, state, priority active, and inactive links.

```
Router# show lacp multichassis group 100
Interchassis Redundancy Group 100
Operational LACP Parameters:
RG State:     Synchronized
System-Id:    200.000a.f331.2680
ICCP Version: 0
Backbone Uplink Status: Connected
Local Configuration:
Node-id:   0
System-Id: 200.000a.f331.2680
Peer Information:
State:        Up
Node-id:      7
System-Id:    2000.0014.6a8b.c680
ICCP Version: 0
State Flags: Active            - A
             Standby           - S
             Down              - D
             AdminDown         - AD
             Standby Reverting - SR
             Unknown           - U

mLACP Channel-groups
Channel    State      Priority     Active Links   Inactive Links
 Group   Local/Peer  Local/Peer     Local/Peer      Local/Peer
   1        A/S     28000/32768        4/4             0/0
```

show lacp multichassis port-channel

Use the **show lacp multichassis port-channel** command to display the interface port-channel value channel group, LAG state, priority, inactive links peer configuration, and standby links.

```
Router# show lacp multichassis port-channel1
Interface Port-channel1
Local Configuration:
Address: 000a.f331.2680
Channel Group: 1
State: Active
LAG State: Up
Priority: 28000
Inactive Links: 0
Total Active Links: 4
           Bundled: 4
          Selected: 4
           Standby: 0
        Unselected: 0
```

```
Peer Configuration:
Interface: Port-channel1
Address: 0014.6a8b.c680
Channel Group: 1
State: Standby
LAG State: Up
Priority: 32768
Inactive Links: 0
Total Active Links: 4
                           Bundled: 0
          Selected: 0
           Standby: 4
        Unselected: 0
```

show mpls ldp iccp

Use the **show mpls ldp iccp** command to display the LDP session and ICCP state information.

```
Router# show mpls ldp iccp
ICPM RGID Table
  iccp:
    rg_id: 100, peer addr: 172.3.3.3
    ldp_session 0x3, client_id 0
    iccp state: ICPM_ICCP_CONNECTED
    app type: MLACP
        app state: ICPM_APP_CONNECTED, ptcl ver: 0
ICPM RGID Table total ICCP sessions: 1
ICPM LDP Session Table
  iccp:
    rg_id: 100, peer addr: 172.3.3.3
    ldp_session 0x3, client_id 0
    iccp state: ICPM_ICCP_CONNECTED
    app type: MLACP
        app state: ICPM_APP_CONNECTED, ptcl ver: 0
ICPM LDP Session Table total ICCP sessions: 1
```

show mpls l2transport

Use the **show mpls l2transport** command to display the local interface and session details, destination address, and the status.

```
Router# show mpls l2transport vc 4000
Local intf     Local circuit              Dest address    VC ID      Status
-------------  -------------------------- --------------- ---------- ----------
VFI VPLS       VFI                        172.2.2.2       4000       UP
VFI VPLS       VFI                        172.4.4.4   4000       UP
```

show etherchannel summary

Use the **show etherchannel summary** command to display the status and identity of the mLACP member links.

```
Router# show etherchannel summary
Flags:  D - down        P/bndl - bundled in port-channel
        I - stand-alone s/susp - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator
```

```
        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1 Po1(RU) LACP Gi0/0/1(bndl-act) Gi0/0/2(bndl-act) Gi0/0/3(bndl-act) Gi0/0/4(bndl-act)

RU - L3 port-channel UP State
SU - L2 port-channel UP state
P/bndl -  Bundled
S/susp  - Suspended
```

show lacp internal

Use the **show lacp internal** command to display the device, port, and member-link information.

```
Router# 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 1
                            LACP port     Admin     Oper    Port        Port
Port      Flags   State     Priority      Key       Key     Number      State
Gi0/0/1   FA      bndl-act  2             0x1       0x1     0xB002      0x3D
Gi0/0/2   FA      bndl-act  2             0x1       0x1     0xB003      0x3D
Gi0/0/3   FA      bndl-act  2             0x1       0x1     0xB004      0x3D
Gi0/0/4   FA      bndl-act  2             0x1       0x1     0xB005      0x3D

Peer (ASR903-PE4) mLACP member links

Gi0/0/1   FA      bndl-sby  32768         0x1       0x1     0xC002      0xD
Gi0/0/2   FA      bndl-sby  32768         0x1       0x1     0xC003      0xD
Gi0/0/3   FA      bndl-sby  32768         0x1       0x1     0xC004      0xD
Gi0/0/0   FA      bndl-sby  32768         0x1       0x1     0xC001      0xD
```

Example Verifying VPLS on a Standby PoA

The **show** commands in this section can be used to display statistics and configuration parameters to verify the operation of the mLACP feature:

show lacp multichassis group

Use the **show lacp multichassis group** *interchassis group number* command to display the LACP parameters, local configuration, status of the backbone uplink, peer information, node ID, channel, state, priority, active, and inactive links.

```
Router# show lacp multichassis group 100
Interchassis Redundancy Group 100
Operational LACP Parameters:
RG State:     Synchronized
System-Id:    200.000a.f331.2680
```

```
ICCP Version: 0
Backbone Uplink Status: Connected
Local Configuration:
Node-id:   7
System-Id: 2000.0014.6a8b.c680
Peer Information:
State:        Up
Node-id:      0
System-Id:    200.000a.f331.2680
ICCP Version: 0
State Flags: Active            - A
             Standby           - S
             Down              - D
             AdminDown         - AD
             Standby Reverting - SR
             Unknown           - U

mLACP Channel-groups
Channel    State      Priority     Active Links   Inactive Links
 Group   Local/Peer  Local/Peer     Local/Peer      Local/Peer
   1        S/A     32768/28000        4/4             0/0
```

show lacp multichassis portchannel

Use the **show lacp multichassis portchannel** command to display the interface port-channel value channel group, LAG state, priority, inactive links peer configuration, and standby links.

```
Router# show lacp multichassis port-channel1
Interface Port-channel1
Local Configuration:
Address: 0014.6a8b.c680
Channel Group: 1
State: Standby
LAG State: Up
Priority: 32768
Inactive Links: 0
Total Active Links: 4
           Bundled: 0
          Selected: 0
           Standby: 4
        Unselected: 0
Peer Configuration:
Interface: Port-channel1
Address: 000a.f331.2680
Channel Group: 1
State: Active
LAG State: Up
Priority: 28000
Inactive Links: 0
Total Active Links: 4
                           Bundled: 4
          Selected: 4
           Standby: 0
        Unselected: 0
```

show mpls ldp iccp

Use the **show mpls ldp iccp** command to display the LDP session and ICCP state information.

```
Router# show mpls ldp iccp
ICPM RGID Table
```

```
  iccp:
    rg_id: 100, peer addr: 172.1.1.1
    ldp_session 0x2, client_id 0
    iccp state: ICPM_ICCP_CONNECTED
    app type: MLACP
        app state: ICPM_APP_CONNECTED, ptcl ver: 0
ICPM RGID Table total ICCP sessions: 1
ICPM LDP Session Table
  iccp:
    rg_id: 100, peer addr: 172.1.1.1
    ldp_session 0x2, client_id 0
    iccp state: ICPM_ICCP_CONNECTED
    app type: MLACP
        app state: ICPM_APP_CONNECTED, ptcl ver: 0
ICPM LDP Session Table total ICCP sessions: 1
```

show mpls l2transport

Use the **show mpls l2transport** command to display the local interface and session details, destination address, and status.

```
Router# show mpls l2transport vc 4000
Local intf     Local circuit           Dest address    VC ID      Status
-------------  ---------------------- --------------- ---------- ----------
VFI VPLS       VFI                     172.2.2.2       4000       UP
VFI VPLS       VFI                     172.4.4.4       4000       UP
```

show etherchannel summary

Use the **show etherchannel summary** command to display the status and identity of the mLACP member links.

```
Router# show etherchannel summary

Flags:  D - down        P/bndl - bundled in port-channel
        I - stand-alone s/susp - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1 Po1(RU) LACP Gi0/0/0(bndl-sby) Gi0/0/1(bndl-sby) Gi0/0/2(bndl-sby) Gi0/0/3(bndl-sby)

RU - L3 port-channel UP State
SU - L2 port-channel UP state
P/bndl -  Bundled
S/susp  - Suspended
```

show lacp internal

Use the **show lacp internal** command to display the device, port, and member- link information.

```
Router# 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 1
                            LACP port     Admin     Oper    Port        Port
Port      Flags   State     Priority      Key       Key     Number      State
Gi0/0/0   FA      bndl-sby  32768         0x1       0x1     0xC001      0xD
Gi0/0/1   FA      bndl-sby  32768         0x1       0x1     0xC002      0xD
Gi0/0/2   FA      bndl-sby  32768         0x1       0x1     0xC003      0xD
Gi0/0/3   FA      bndl-sby  32768         0x1       0x1     0xC004      0xD

Peer (ASR903-PE3) mLACP member links

Gi0/0/2   FA      bndl-act  2             0x1       0x1     0xB003      0x3D
Gi0/0/3   FA      bndl-act  2             0x1       0x1     0xB004      0x3D
Gi0/0/4   FA      bndl-act  2             0x1       0x1     0xB005      0x3D
Gi0/0/1   FA      bndl-act  2             0x1       0x1     0xB002      0x3D
```

Glossary

active attachment circuit—The link that is actively forwarding traffic between the DHD and the active PoA.

active PW—The pseudowire that is forwarding traffic on the active PoA.

BD—bridge domain.

BFD—bidirectional forwarding detection.

DHD—dual-homed device. A node that is connected to two switches over a multichassis link aggregation group for the purpose of redundancy.

DHN—dual-homed network. A network that is connected to two switches to provide redundancy.

H-VPLS—Hierarchical Virtual Private LAN Service.

ICC—Interchassis Communication Channel.

ICCP—Interchassis Communication Protocol.

ICPM—Interchassis Protocol Manager.

ICRM—Interchassis Redundancy Manager.

LACP—Link Aggregation Control Protocol.

LAG—link aggregation group.

LDP—Link Distribution Protocol.

MCEC—Multichassis EtherChannel.

mLACP—Multichassis LACP.

PoA—point of attachment. One of a pair of switches running multichassis link aggregation group with a DHD.

PW-RED—pseudowire redundancy.

standby attachment circuit—The link that is in standby mode between the DHD and the standby PoA.

standby PW—The pseudowire that is in standby mode on either an active or a standby PoA.

uPE—user-facing Provider Edge.

VPLS—Virtual Private LAN Service.

VPWS—Virtual Private Wire Service.