Configuring Ethernet OAM

This module describes the configuration of Ethernet Operations, Administration, and Maintenance (OAM) on the Cisco ASR 9000 Series Aggregation Services Routers.

Feature History for Configuring Ethernet OAM

Release	Modification
Release 3.7.2	Support for the following features was introduced: • Ethernet Link OAM • Ethernet CFM
Release 3.7.3	Support for the CFM Exploratory Linktrace feature was introduced.
Release 3.9.0	Support for the Ethernet SLA feature was introduced.
Release 3.9.1	Support for the following features was introduced: • Ethernet CFM on Link Aggregation Group (LAG) interfaces (Ethernet bundle interfaces), Ethernet and bundle sub interfaces, and LAG member (bundle member) interfaces. • EFD • AIS • Flexible tagging • The **ethernet cfm mep domain** command is replaced by the **ethernet cfm** and **mep domain** commands.

Release 4.0.0	Support for the following features was introduced:
	• The **action link-fault** command is replaced by the **action uni-directional link fault** command.
	• The **efd** keyword is added to put an interface into the line protocol down state, as an option for the following commands:
	  • **action capabilities-conflict**
	  • **action discovery-timeout**
	  • **action session-down**
	  • **action uni-directional link-fault**
	• Uni-directional link-fault detection to identify local link-faults and send notification to a remote Ethernet OAM peer using the **uni-directional link-fault detection** command.
	• Support for the following enhancements to Ethernet SLA was added:
	  • Support for on-demand Ethernet SLA operations using the **ethernet sla on-demand operation** commands.
	  • One-way delay and jitter measurements using the following new keyword options for the **statistics measure** command: **one-way-delay-ds. one-way-delay-sd. one-way-jitter-ds. one-way-jitter-sd**
	  • Specification of a test pattern to pad loopback packets when measuring delay.
	  • Displaying the time when the minimum (Min) and maximum (Max) values of a statistic occurred in the measurement time period in the **show ethernet sla statistics detail** command.

Release 4.0.1	Support for Ethernet CFM on Multi-Chassis Link Aggregation Groups (MC-LAG) was added.
Release 4.1.0	Support for the following feature was introduced: • E-LMI • Timestamps for delay packets were changed from being derived by the sytem time-of-day (NTP) clock to the DTI timing input on the clock-interfaces on the RSP. • CFM Y.1731 ITU Carrier Code (ICC)-based MEG ID (MAID) format.
Release 4.2.0	Support for Unidirectional Link Detection Protocol (UDLD) was introduced.
Release 4.3.0	Support for ITU-T Y.1731 Synthetic Loss Measurement was introduced.
Release 4.3.1	Support for ITU-T Y.1731 Loss Measurement was introduced.

Release 5.1.0	Support for Ethernet Data Plane Loopback was introduced.
Release 5.1.2	Support for Ethernet CFM down MEP was included.
Release 5.3.2	CFM support on the Bundle over Bundle is limited as follows: CFM software offload is not supported on the satellite access bundles (sub) interface over bundle ICL. If CFM is configured on any satellite access bundle interface over bundle ICL, bundle-offload configuration can not be applied. If CFM is configured only on interface in ASR 9000 series other than satellite access bundle interface over bundle ICL, then bundle-offload configuration can be applied.
Release 7.1.1	Support for CFM adaptive bandwidth notifications was introduced.
Release 7.1.15	Support for CFM Hardware Offload on ASR 9000 5th Generation High Density line cards was introduced.
Release 7.4.2	Support to calculate Bit Error Rate by using Cyclic Redundancy Check was introduced.

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- How to Configure Ethernet OAM, on page 48
- Configuration Examples for Ethernet OAM, on page 111
- CFM Adaptive Bandwidth Notifications, on page 135

Prerequisites for Configuring Ethernet OAM

You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

Before configuring Ethernet OAM, confirm that at least one of the Gigabit Ethernet line cards or Cisco ASR 9000 Enhanced Ethernet line cards are installed on the router.

Information About Configuring Ethernet OAM

To configure Ethernet OAM, you should understand the following concepts:

Ethernet Link OAM

Table 1: Feature History Table

Ethernet as a Metro Area Network (MAN) or a Wide Area Network (WAN) technology benefits greatly from the implementation of Operations, Administration and Maintenance (OAM) features. Ethernet link OAM features allow Service Providers to monitor the quality of the connections on a MAN or WAN. Service providers can monitor specific events, take actions on events, and if necessary, put specific interfaces into

loopback mode for troubleshooting. Ethernet link OAM operates on a single, physical link and it can be configured to monitor either side or both sides of that link.

Ethernet link OAM can be configured in the following ways:

- A Link OAM profile can be configured, and this profile can be used to set the parameters for multiple interfaces.
- Link OAM can be configured directly on an interface.

  When an interface is also using a link OAM profile, specific parameters that are set in the profile can be overridden by configuring a different value directly on the interface.

An Ethernet Link OAM profile simplifies the process of configuring EOAM features on multiple interfaces. An Ethernet OAM profile, and all of its features, can be referenced by other interfaces, allowing other interfaces to inherit the features of that Ethernet OAM profile.

Individual Ethernet link OAM features can be configured on individual interfaces without being part of a profile. In these cases, the individually configured features always override the features in the profile.

The preferred method of configuring custom EOAM settings is to create an EOAM profile in Ethernet configuration mode and then attach it to an individual interface or to multiple interfaces.

When an EOAM packet is received on any one of the AC interfaces on which EOAM is not configured, the AC interface multicasts the received EOAM packets to other AC interfaces that are part of EVPN-BD to reach the peer. When an EOAM is enabled on the bundle member in the peer, it punts the packet to the CPU in the peer. Also, the EOAM flaps the bundle member as the local or remote Key of the received EOAM does not match.

These standard Ethernet Link OAM features are supported on the router:

Neighbor Discovery

Neighbor discovery enables each end of a link to learn the OAM capabilities of the other end and establish an OAM peer relationship. Each end also can require that the peer have certain capabilities before it will establish a session. You can configure certain actions to be taken if there is a capabilities conflict or if a discovery process times out, using the **action capabilities-conflict** or **action discovery-timeout** commands.

Link Monitoring

Link monitoring enables an OAM peer to monitor faults that cause the quality of a link to deteriorate over time. When link monitoring is enabled, an OAM peer can be configured to take action when the configured thresholds are exceeded.

MIB Retrieval

MIB retrieval enables an OAM peer on one side of an interface to get the MIB variables from the remote side of the link. The MIB variables that are retrieved from the remote OAM peer are READ ONLY.

Miswiring Detection (Cisco-Proprietary)

Miswiring Detection is a Cisco-proprietary feature that uses the 32-bit vendor field in every Information OAMPDU to identify potential miswiring cases.

Remote Loopback

Remote loopback enables one side of a link to put the remote side of the link into loopback mode for testing. When remote loopback is enabled, all packets initiated by the primary side of the link are looped back to the primary side, unaltered by the remote side. In remote loopback mode, the remote side is not allowed to inject any data into the packets.

SNMP Traps

SNMP traps can be enabled or disabled on an Ethernet OAM interface.

Unidirectional Link Fault Detection

Unidirectional link fault detection describes an Ethernet link OAM function that runs directly on physical Ethernet interfaces (not VLAN subinterfaces or bundles) that uses a defined link fault message to signal link faults to a remote host. Unidirectional link fault detection offers similar functionality to Gigabit Ethernet and Ten Gigabit Ethernet hardware-level signaling of a link fault, but it is done at a higher protocol layer as part of Ethernet link OAM. The hardware function uses the Remote Fault Indication bit set in a frame that is signaled out-of-band, where unidirectional link fault detection signals the error using an OAMPDU.

Unidirectional link fault detection only applies to a single, physical link. When the remote host receives the link fault message, the interface can be shut down for all higher-layer protocols, and specifically, Layer 2 switching and Layer 3 routing protocols. While the fault is detected, a link fault message is sent periodically to the remote host. Once a fault is no longer detected, the link fault message is no longer sent, and the remote host can bring back the interface.

Unidirectional link fault detection is configured using the **uni-directional link-fault detection** command, and does not affect how the receipt of link-fault messages are handled by the router. Actions to be taken for the receipt of link-fault messages are configured using the **action uni-directional link-fault** command.

Ethernet CFM

Ethernet Connectivity Fault Management (CFM) is a service-level OAM protocol that provides tools for monitoring and troubleshooting end-to-end Ethernet services per VLAN. This includes proactive connectivity monitoring, fault verification, and fault isolation. CFM uses standard Ethernet frames and can be run on any physical media that is capable of transporting Ethernet service frames. Unlike most other Ethernet protocols which are restricted to a single physical link, CFM frames can transmit across the entire end-to-end Ethernet network.

CFM is defined in two standards:

- IEEE 802.1ag—Defines the core features of the CFM protocol.
- ITU-T Y.1731—Redefines, but maintains compatibility with the features of IEEE 802.1ag, and defines some additional features.

Ethernet CFM on the Cisco ASR 9000 Series Router supports these functions of ITU-T Y.1731:

- ETH-CC, ETH-RDI, ETH-LB, ETH-LT—These are equivalent to the corresponding features defined in IEEE 802.1ag.

Note The Linktrace responder procedures defined in IEEE 802.1ag are used rather than the procedures defined in Y.1731; however, these are interoperable.

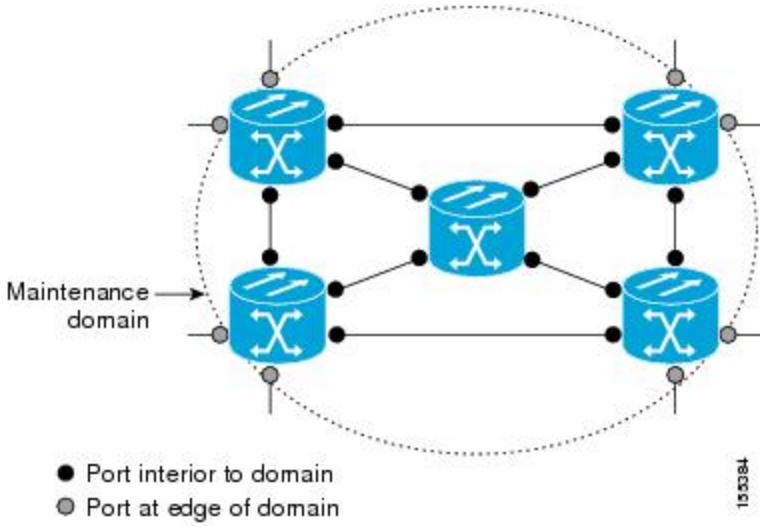
- ETH-AIS—The reception of ETH-LCK messages is also supported.
- ETH-DM, ETH-SLM—This is supported with the Ethernet SLA feature. For more information about Ethernet SLA, see the Ethernet SLA.

To understand how the CFM maintenance model works, you need to understand these concepts and features:

Maintenance Domains

A *maintenance domain* describes a management space for the purpose of managing and administering a network. A domain is owned and operated by a single entity and defined by the set of interfaces internal to it and at its boundary, as shown in this figure.

Figure 1: CFM Maintenance Domain



A maintenance domain is defined by the bridge ports that are provisioned within it. Domains are assigned maintenance levels, in the range of 0 to 7, by the administrator. The level of the domain is useful in defining the hierarchical relationships of multiple domains.

CFM maintenance domains allow different organizations to use CFM in the same network, but independently. For example, consider a service provider who offers a service to a customer, and to provide that service, they use two other operators in segments of the network. In this environment, CFM can be used in the following ways:

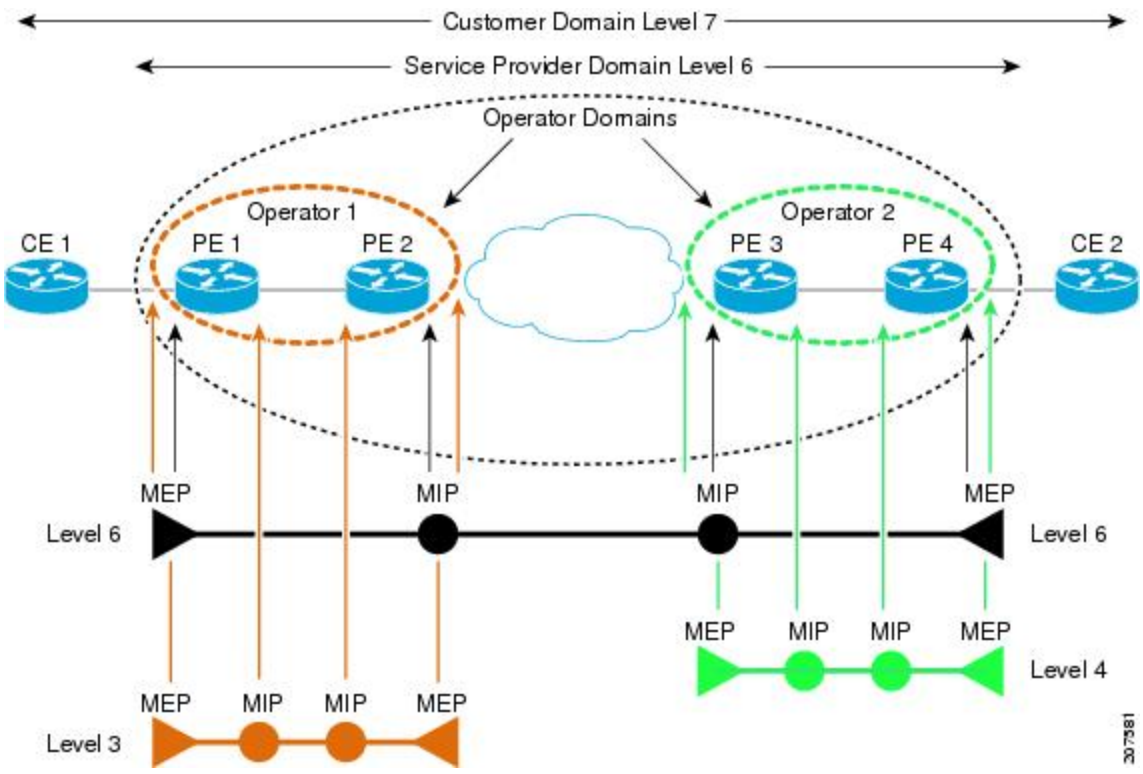
- The customer can use CFM between their CE devices, to verify and manage connectivity across the whole network.
- The service provider can use CFM between their PE devices, to verify and manage the services they are providing.
- Each operator can use CFM within their operator network, to verify and manage connectivity within their network.

Each organization uses a different CFM maintenance domain.

This figure shows an example of the different levels of maintenance domains in a network.

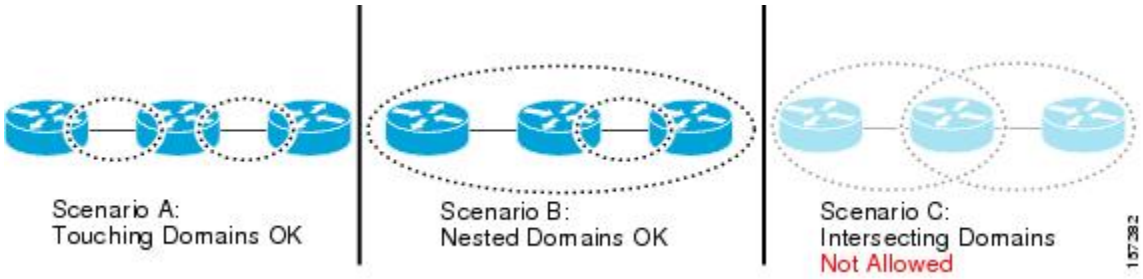
Note In CFM diagrams, the conventions are that triangles represent MEPs, pointing in the direction that the MEP sends CFM frames, and circles represent MIPs. For more information about MEPs and MIPs, see the Maintenance Points.

Figure 2: Different CFM Maintenance Domains Across a Network



To ensure that the CFM frames for each domain do not interfere with each other, each domain is assigned a maintenance level, between 0 and 7. Where domains are nested, as in this example, the encompassing domain must have a higher level than the domain it encloses. In this case, the domain levels must be negotiated between the organizations involved. The maintenance level is carried in all CFM frames that relate to that domain.

CFM maintenance domains may touch or nest, but cannot intersect. This figure illustrates the supported structure for touching and nested domains, and the unsupported intersection of domains.



Services

A CFM service allows an organization to partition its CFM maintenance domain, according to the connectivity within the network. For example, if the network is divided into a number of virtual LANs (VLANs), a CFM service is created for each of these. CFM can then operate independently in each service. It is important that the CFM services match the network topology, so that CFM frames relating to one service cannot be received in a different service. For example, a service provider may use a separate CFM service for each of their customers, to verify and manage connectivity between that customer's end points.

A CFM service is always associated with the maintenance domain that it operates within, and therefore with that domain's maintenance level. All CFM frames relating to the service carry the maintenance level of the corresponding domain.

Note CFM Services are referred to as *Maintenance Associations* in IEEE 802.1ag and as *Maintenance Entity Groups* in ITU-T Y.1731.

Maintenance Points

A CFM *Maintenance Point* (MP) is an instance of a particular CFM service on a specific interface. CFM only operates on an interface if there is a CFM maintenance point on the interface; otherwise, CFM frames are forwarded transparently through the interface.

A maintenance point is always associated with a particular CFM service, and therefore with a particular maintenance domain at a particular level. Maintenance points generally only process CFM frames at the same level as their associated maintenance domain. Frames at a higher maintenance level are always forwarded transparently, while frames at a lower maintenance level are normally dropped. This helps enforce the maintenance domain hierarchy described in the Maintenance Domains, and ensures that CFM frames for a particular domain cannot leak out beyond the boundary of the domain.

There are two types of MP:

- Maintenance End Points (MEPs)—Created at the edge of the domain. Maintenance end points (MEPs) are members of a particular service within a domain and are responsible for sourcing and sinking CFM frames. They periodically transmit continuity check messages and receive similar messages from other MEPs within their domain. They also transmit traceroute and loopback messages at the request of the administrator. MEPs are responsible for confining CFM messages within the domain.
- Maintenance Intermediate Points (MIPs)—Created in the middle of the domain. Unlike MEPS, MIPs do allow CFM frames at their own level to be forwarded.

MIP Creation

Unlike MEPs, MIPs are not explicitly configured on each interface. MIPs are created automatically according to the algorithm specified in the CFM 802.1ag standard. The algorithm, in brief, operates as follows for each interface:

- The bridge-domain or cross-connect for the interface is found, and all services associated with that bridge-domain or cross-connect are considered for MIP auto-creation.
- The level of the highest-level MEP on the interface is found. From among the services considered above, the service in the domain with the lowest level that is higher than the highest MEP level is selected. If there are no MEPs on the interface, the service in the domain with the lowest level is selected.

- The MIP auto-creation configuration (**mip auto-create** command) for the selected service is examined to determine whether a MIP should be created.

Note Configuring a MIP auto-creation policy for a service does not guarantee that a MIP will automatically be created for that service. The policy is only considered if that service is selected by the algorithm first.

MEP and CFM Processing Overview

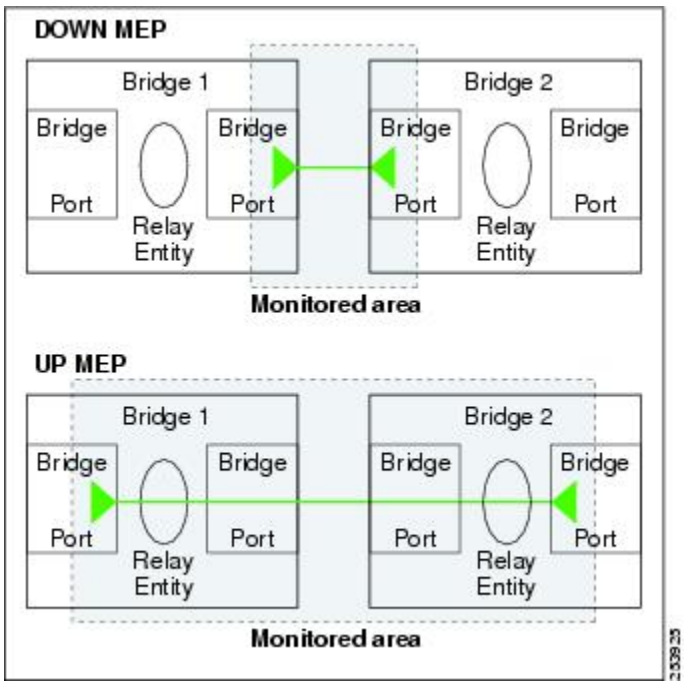
The boundary of a domain is an interface, rather than a bridge or host. Therefore, MEPs can be sub-divided into two categories:

- Down MEPs—Send CFM frames from the interface where they are configured, and process CFM frames received on that interface. Down MEPs transmit AIS messages upward (toward the bridge domain or cross-connect).
- Up MEPs—Send frames into the bridge relay function, as if they had been received on the interface where the MEP is configured. They process CFM frames that have been received on other interfaces, and have been switched through the bridge relay function as if they are going to be sent out of the interface where the MEP is configured. Up MEPs transmit AIS messages downward (toward the wire). However, AIS packets are only sent when there is a MIP configured on the same interface as the MEP and at the level of the MIP.

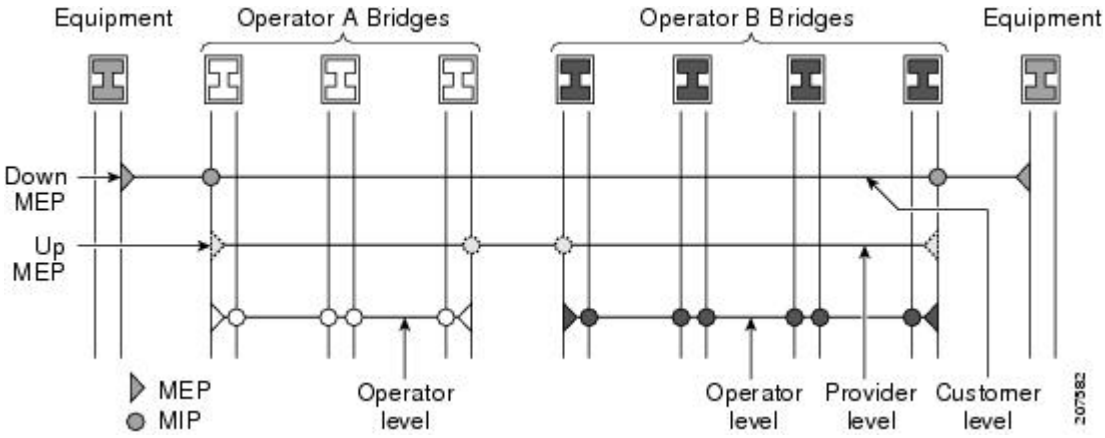
Note The terms *Down MEP* and *Up MEP* are defined in the IEEE 802.1ag and ITU-T Y.1731 standards, and refer to the direction that CFM frames are sent from the MEP. The terms should not be confused with the operational status of the MEP.

This figure illustrates the monitored areas for Down and Up MEPs.

Figure 3: Monitored Areas for Down and Up MEPs



This figure shows maintenance points at different levels. Because domains are allowed to nest but not intersect (see Figure 3), a MEP at a low level always corresponds with a MEP or MIP at a higher level. In addition, only a single MIP is allowed on any interface—this is generally created in the lowest domain that exists at the interface and that does not have a MEP.



MIPs and Up MEPs can only exist on switched (Layer 2) interfaces, because they send and receive frames from the bridge relay function. Down MEPs can be created on switched (Layer 2) or routed (Layer 3) interfaces.

MEPs continue to operate normally if the interface they are created on is blocked by the Spanning Tree Protocol (STP); that is, CFM frames at the level of the MEP continue to be sent and received, according to the direction of the MEP. MEPs never allow CFM frames at the level of the MEP to be forwarded, so the STP block is maintained.

MIPs also continue to receive CFM frames at their level if the interface is STP blocked, and can respond to any received frames. However, MIPs do not allow CFM frames at the level of the MIP to be forwarded if the interface is blocked.

Note A separate set of CFM maintenance levels is created every time a VLAN tag is pushed onto the frame. Therefore, if CFM frames are received on an interface which pushes an additional tag, so as to "tunnel" the frames over part of the network, the CFM frames will not be processed by any MPs within the tunnel, even if they are at the same level. For example, if a CFM MP is created on an interface with an encapsulation that matches a single VLAN tag, any CFM frames that are received at the interface that have two VLAN tags will be forwarded transparently, regardless of the CFM level.

CFM Protocol Messages

The CFM protocol consists of a number of different message types, with different purposes. All CFM messages use the CFM EtherType, and carry the CFM maintenance level for the domain to which they apply.

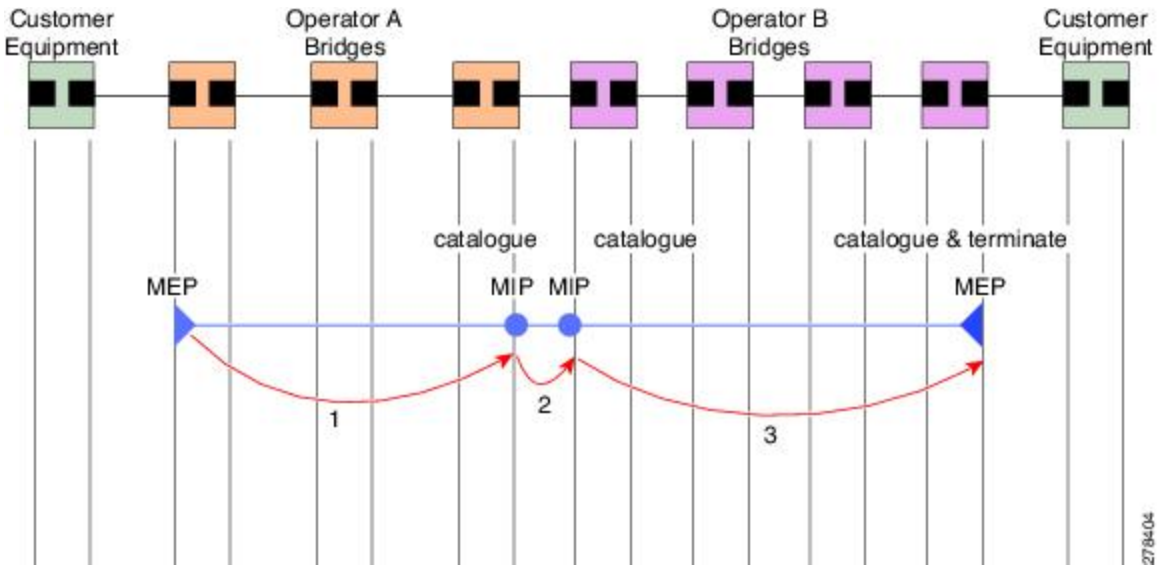
This section describes the following CFM messages:

Continuity Check (IEEE 802.1ag and ITU-T Y.1731)

Continuity Check Messages (CCMs) are "heartbeat" messages exchanged periodically between all the MEPs in a service. Each MEP sends out multicast CCMs, and receives CCMs from all the other MEPs in the service—these are referred to as *peer MEPs*. This allows each MEP to discover its peer MEPs, and to verify that there is connectivity between them.

MIPs also receive CCMs. MIPs use the information to build a MAC learning database that is used when responding to Linktrace. For more information about Linktrace, see the Linktrace (IEEE 802.1ag and ITU-T Y.1731).

Figure 4: Continuity Check Message Flow



All the MEPs in a service must transmit CCMs at the same interval. IEEE 802.1ag defines 7 possible intervals that can be used:

- 10ms (applicable on the Cisco ASR 9000 Enhanced Ethernet Line Card)
- 100ms
- 1s
- 10s
- 1 minute
- 10 minutes

A MEP detects a loss of connectivity with one of its peer MEPs when some number of CCMs have been missed. This occurs when sufficient time has passed during which a certain number of CCMs were expected, given the CCM interval. This number is called the *loss threshold*, and is usually set to 3.

CCM messages carry a variety of information that allows different defects to be detected in the service. This information includes:

- A configured identifier for the domain of the transmitting MEP. This is referred to as the Maintenance Domain Identifier (MDID).
- A configured identifier for the service of the transmitting MEP. This is referred to as the Short MA Name (SMAN). Together, the MDID and the SMAN make up the Maintenance Association Identifier (MAID). The MAID must be configured identically on every MEP in the service.
- A configured numeric identifier for the MEP (the MEP ID). Each MEP in the service must be configured with a different MEP ID.
- A sequence number.
- A Remote Defect Indication (RDI). Each MEP includes this in the CCMs it is sending, if it has detected a defect relating to the CCMs it is receiving. This notifies all the MEPs in the service that a defect has been detected somewhere in the service.
- The interval at which CCMs are being transmitted.
- The status of the interface where the MEP is operating—for example, whether the interface is up, down, STP blocked, and so on.

Note The status of the interface (up/down) should not be confused with the direction of any MEPs on the interface (Up MEPs/Down MEPs).

These defects can be detected from received CCMs:

- Interval mismatch—The CCM interval in the received CCM does not match the interval that the MEP is sending CCMs.
- Level mismatch—A MEP has received a CCM carrying a lower maintenance level than the MEPs own level.
- Loop—A CCM is received with the source MAC address equal to the MAC address of the interface where the MEP is operating.
- Configuration error—A CCM is received with the same MEP ID as the MEP ID configured for the receiving MEP.

- Cross-connect—A CCM is received with an MAID that does not match the locally configured MAID. This generally indicates a VLAN misconfiguration within the network, such that CCMs from one service are leaking into a different service.
- Peer interface down—A CCM is received that indicates the interface on the peer is down.
- Remote defect indication—A CCM is received carrying a remote defect indication.

Note This defect does not cause the MEP to include a remote defect indication in the CCMs that it is sending.

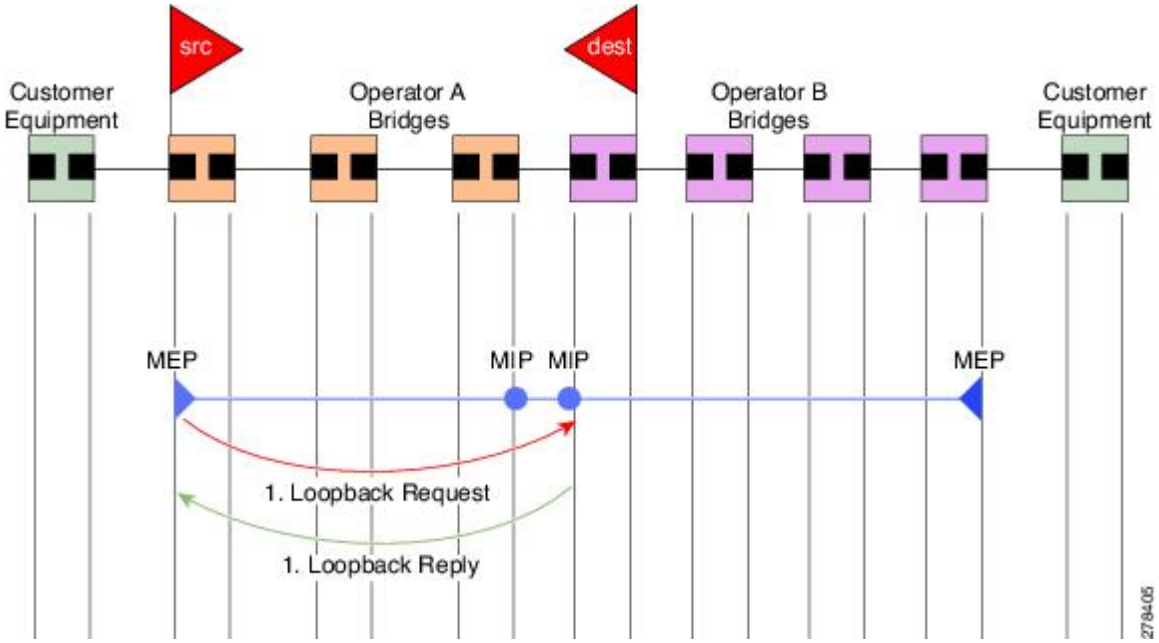
Out-of-sequence CCMs can also be detected by monitoring the sequence number in the received CCMs from each peer MEP. However, this is not considered a CCM defect.

Loopback (IEEE 802.1ag and ITU-T Y.1731)

Loopback Messages (LBM) and Loopback Replies (LBR) are used to verify connectivity between a local MEP and a particular remote MP. At the request of the administrator, a local MEP sends unicast LBMs to the remote MP. On receiving each LBM, the target maintenance point sends an LBR back to the originating MEP. Loopback indicates whether the destination is reachable or not—it does not allow hop-by-hop discovery of the path. It is similar in concept to an ICMP Echo (ping). Since loopback messages are destined for unicast addresses, they are forwarded like normal data traffic, while observing the maintenance levels. At each device that the loopback reaches, if the outgoing interface is known (in the bridge's forwarding database), then the frame is sent out on that interface. If the outgoing interface is not known, then the message is flooded on all interfaces.

This figure shows an example of CFM loopback message flow between a MEP and MIP.

Figure 5: Loopback Messages



Loopback messages can be padded with user-specified data. This allows data corruption to be detected in the network. They also carry a sequence number which allows for out-of-order frames to be detected.

Except for one-way delay and jitter measurements, loopback messages can also be used for Ethernet SLA, if the peer does not support delay measurement.

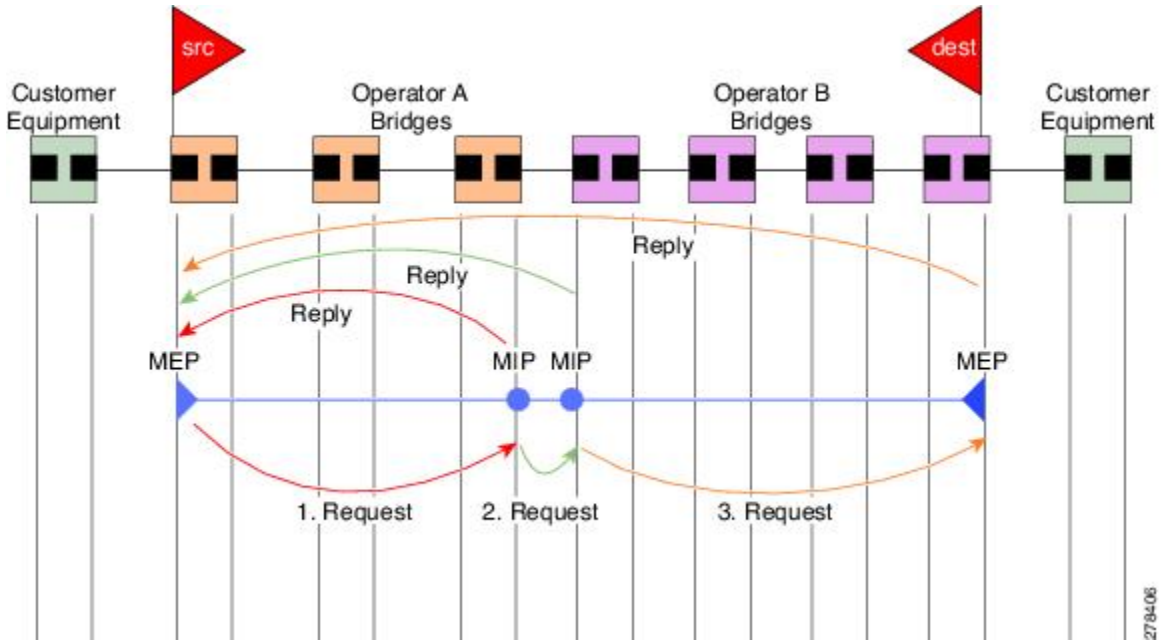
Note The Ethernet CFM loopback function should not be confused with the remote loopback functionality in Ethernet Link OAM (see the Remote Loopback). CFM loopback is used to test connectivity with a remote MP, and only the CFM LBM packets are reflected back, but Ethernet Link OAM remote loopback is used to test a link by taking it out of normal service and putting it into a mode where it reflects back all packets.

Linktrace (IEEE 802.1ag and ITU-T Y.1731)

Linktrace Messages (LTM) and Linktrace Replies (LTR) are used to track the path (hop-by-hop) to a unicast destination MAC address. At the request of the operator, a local MEP sends an LTM. Each hop where there is a maintenance point sends an LTR back to the originating MEP. This allows the administrator to discover connectivity data about the path. It is similar in concept to IP traceroute, although the mechanism is different. In IP traceroute, successive probes are sent, whereas CFM Linktrace uses a single LTM which is forwarded by each MP in the path. LTMs are multicast, and carry the unicast target MAC address as data within the frame. They are intercepted at each hop where there is a maintenance point, and either retransmitted or dropped to discover the unicast path to the target MAC address.

This figure shows an example of CFM linktrace message flow between MEPs and MIPs.

Figure 6: Linktrace Message Flow



The linktrace mechanism is designed to provide useful information even after a network failure. This allows it to be used to locate failures, for example after a loss of continuity is detected. To achieve this, each MP maintains a CCM Learning Database. This maps the source MAC address for each received CCM to the

interface through which the CCM was received. It is similar to a typical bridge MAC learning database, except that it is based only on CCMs and it times out much more slowly—on the order of days rather than minutes.

Note In IEEE 802.1ag, the CCM Learning Database is referred to as the MIP CCM Database. However, it applies to both MIPs and MEPs.

In IEEE 802.1ag, when an MP receives an LTM message, it determines whether to send a reply using the following steps:

1. The target MAC address in the LTM is looked up in the bridge MAC learning table. If the MAC address is known, and therefore the egress interface is known, then an LTR is sent.
2. If the MAC address is not found in the bridge MAC learning table, then it is looked up in the CCM learning database. If it is found, then an LTR is sent.
3. If the MAC address is not found, then no LTR is sent (and the LTM is not forwarded).

If the target MAC has never been seen previously in the network, the linktrace operation will not produce any results.

Note IEEE 802.1ag and ITU-T Y.1731 define slightly different linktrace mechanisms. In particular, the use of the CCM learning database and the algorithm described above for responding to LTM messages are specific to IEEE 802.1ag. IEEE 802.1ag also specifies additional information that can be included in LTRs. Regardless of the differences, the two mechanisms are interoperable.

Exploratory Linktrace (Cisco)

Exploratory Linktrace is a Cisco extension to the standard linktrace mechanism described above. It has two primary purposes:

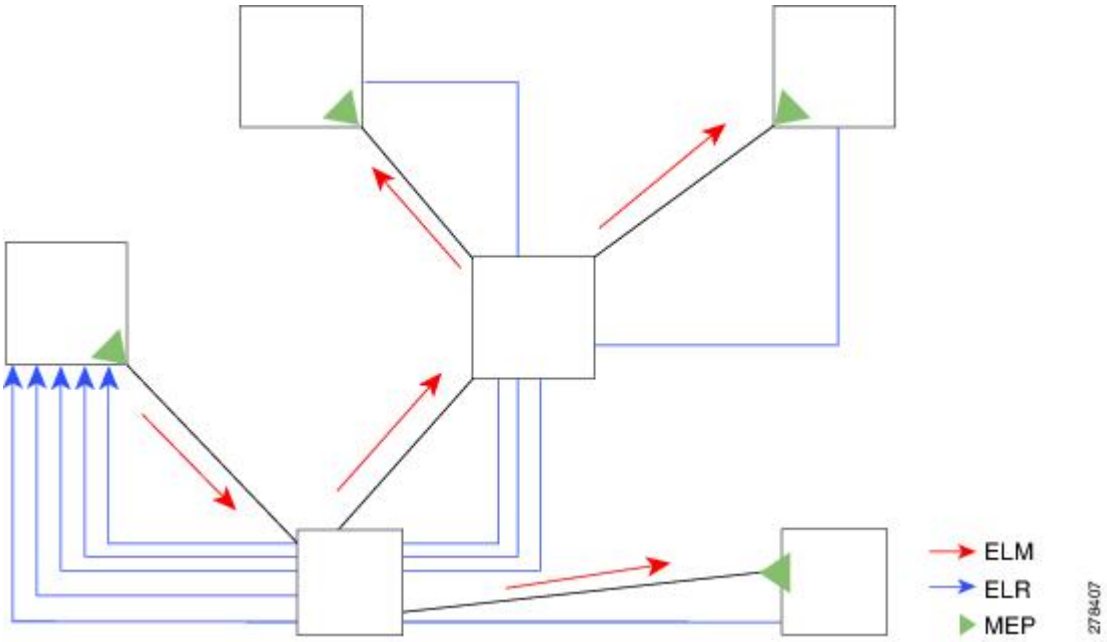
- Provide a mechanism to locate faults in cases where standard linktrace does not work, such as when a MAC address has never been seen previously in the network. For example, if a new MEP has been provisioned but is not working, standard linktrace does not help isolate a problem because no frames will ever have been received from the new MEP. Exploratory Linktrace overcomes this problem.
- Provide a mechanism to map the complete active network topology from a single node. This can only be done currently by examining the topology (for example, the STP blocking state) on each node in the network individually, and manually combining this information to create the overall active topology map. Exploratory linktrace allows this to be done automatically from a single node.

Exploratory Linktrace is implemented using the Vendor Specific Message (VSM) and Vendor Specific Reply (VSR) frames defined in ITU-T Y.1731. These allow vendor-specific extensions to be implemented without degrading interoperability. Exploratory Linktrace can safely be deployed in a network that includes other CFM implementations because those implementations will simply ignore the Exploratory Linktrace messages.

Exploratory Linktrace is initiated at the request of the administrator, and results in the local MEP sending a multicast Exploratory Linktrace message. Each MP in the network that receives the message sends an Exploratory Linktrace reply. MIPs that receive the message also forward it on. The initiating MEP uses all the replies to create a tree of the overall network topology.

This figure show an example of the Exploratory Linktrace message flow between MEPs.

Figure 7: Exploratory Linktrace Messages and Replies



To avoid overloading the originating MEP with replies in a large network, responding MPs delay sending their replies for a random amount of time, and that time increases as the size of the network increases.

In a large network, there will be a corresponding large number of replies and the resulting topology map will be equally large. If only a part of the network is of interest, for example, because a problem has already been narrowed down to a small area, then the Exploratory Linktrace can be "directed" to start at a particular MP. Replies will thus only be received from MPs beyond that point in the network. The replies are still sent back to the originating MEP.

Delay and Jitter Measurement (ITU-T Y.1731)

The router supports one-way and two-way delay measurement using two packet types:

- Delay Measurement Message (DMM)
- Delay Measurement Response (DMR)

These packets are unicast similar to loopback messages. The packets carry timestamps generated by the system time-of-day clock to support more accurate delay measurement, and also support an SLA manageability front-end. Beginning in Cisco IOS XR Release 4.1, the DDM & DDR packets carry timestamps derived from the DTI timing input on the clock-interface port on the RSP.

However, unlike loopback messages, these message types can also measure one-way delay and jitter either from destination to source, or from source to destination.

For more information about SLA, see the Ethernet SLA.

Synthetic Loss Measurement (ITU-T Y.1731)

Synthetic Loss Measurement (SLM) is a mechanism that injects synthetic measurement probes, and measures the loss of these probes in order to measure the loss of real data traffic. Each probe packet carries a sequence number, and the sender increments the sequence number by one for each packet that is sent and the receiver can thereby detect the lost packets by looking for missing sequence numbers.

SLM packets contain two sequence numbers; one written by the initiator into the SLM and copied by the responder into the SLR, and the other allocated by the responder and written into the SLR. These are refered to as the source-to-destination (sd) sequence number and the destination-to-source (ds) sequence number respectively.

This figure shows an example of how the sequence numbers are used to calculate the Frame Loss Ratio (FLR) in each direction.

Figure 8: Synthetic Loss Measurement

Loss Measurement (ITU-T Y.1731)

Y.1731 Loss Measurement is a mechanism that measures the actual data traffic loss between a pair of MEPs in a point-to-point Ethernet service. This is in contrast to the Synthetic Loss Measurement, which measures the frame loss of synthetic frames. By using Y.1731 Loss Measurement, you can measure the one-way loss in each direction, for each priority class and also measure the loss aggregated across all priority classes.

To enable loss measurements to be made, each MEP maintains, for each priority class, both source-to-destination and destination-to-source frame counts for its peer MEPs.

There are two Loss Measurement Mechanisms (LMM); namely, single-ended and dual-ended. Cisco IOS XR Software supports only single-ended LMM.

MEP Cross-Check

MEP cross-check supports configuration of a set of expected peer MEPs so that errors can be detected when any of the known MEPs are missing, or if any additional peer MEPs are detected that are not in the expected group.

The set of expected MEP IDs in the service is user-defined. Optionally, the corresponding MAC addresses can also be specified. CFM monitors the set of peer MEPs from which CCMs are being received. If no CCMs are ever received from one of the specified expected peer MEPs, or if a loss of continuity is detected, then a cross-check “missing” defect is detected. Similarly, if CCMs are received from a matching MEP ID but with the wrong source MAC address, a cross-check “missing” defect is detected. If CCMs are subsequently received that match the expected MEP ID, and if specified, the expected MAC address, then the defect is cleared.

Note While loss of continuity can be detected for any peer MEP, it is only treated as a defect condition if cross-check is configured.

If cross-check is configured and CCMs are received from a peer MEP with a MEP ID that is not expected, this is detected as a cross-check “unexpected” condition. However, this is not treated as a defect condition.

Configurable Logging

CFM supports logging of various conditions to syslog. Logging can be enabled independently for each service, and when the following conditions occur:

- New peer MEPs are detected, or loss of continuity with a peer MEP occurs.
- Changes to the CCM defect conditions are detected.
- Cross-check “missing” or “unexpected” conditions are detected.
- AIS condition detected (AIS messages received) or cleared (AIS messages no longer received).
- EFD used to shut down an interface, or bring it back up.

EFD

Ethernet Fault Detection (EFD) is a mechanism that allows Ethernet OAM protocols, such as CFM, to control the “line protocol” state of an interface.

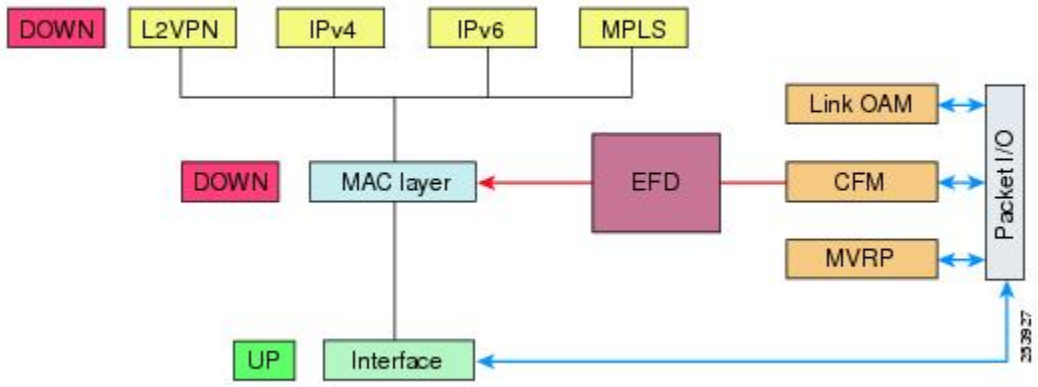
Unlike many other interface types, Ethernet interfaces do not have a line protocol, whose state is independent from that of the interface. For Ethernet interfaces, this role is handled by the physical-layer Ethernet protocol itself, and therefore if the interface is physically up, then it is available and traffic can flow.

EFD changes this to allow CFM to act as the line protocol for Ethernet interfaces. This allows CFM to control the interface state so that if a CFM defect (such as AIS or loss of continuity) is detected with an expected peer MEP, the interface can be shut down. This not only stops any traffic flowing, but also triggers actions in any higher-level protocols to route around the problem. For example, in the case of Layer 2 interfaces, the MAC table would be cleared and MSTP would reconverge. For Layer 3 interfaces, the ARP cache would be cleared and potentially the IGP would reconverge.

Note EFD can only be used for down MEPs. When EFD is used to shut down the interface, the CFM frames continue to flow. This allows CFM to detect when the problem has been resolved, and thus bring the interface backup automatically.

This figure shows CFM detection of an error on one of its sessions EFD signaling an error to the corresponding MAC layer for the interface. This triggers the MAC to go to a down state, which further triggers all higher level protocols (Layer 2 pseudowires, IP protocols, and so on) to go down and also trigger a reconvergence where possible. As soon as CFM detects there is no longer any error, it can signal to EFD and all protocols will once again go active.

Figure 9: CFM Error Detection and EFD Trigger



Flexible VLAN Tagging for CFM

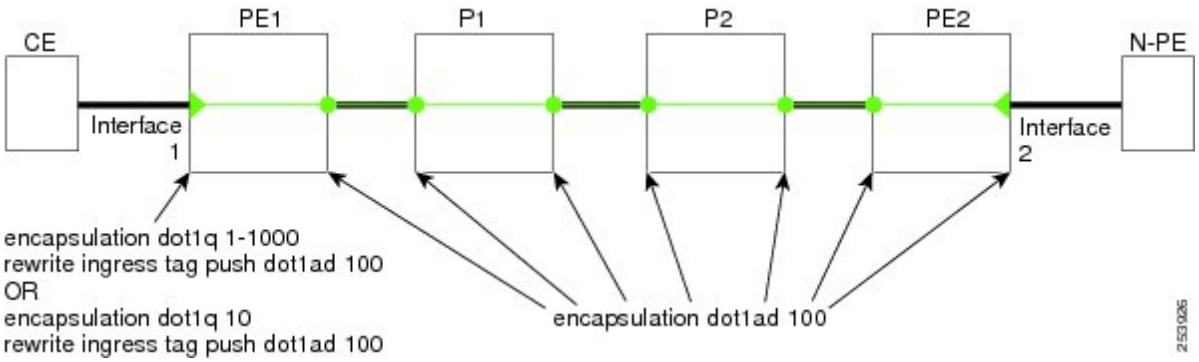
The Flexible VLAN Tagging for CFM feature ensures that CFM packets are sent with the right VLAN tags so that they are appropriately handled as a CFM packet by the remote device. When packets are received by an edge router, they are treated as either CFM packets or data packets, depending on the number of tags in the header. The system differentiates between CFM packets and data packets based on the number of tags in the packet, and forwards the packets to the appropriate paths based on the number of tags in the packet.

CFM frames are normally sent with the same VLAN tags as the corresponding customer data traffic on the interface, as defined by the configured encapsulation and tag rewrite operations. Likewise, received frames are treated as CFM frames if they have the correct number of tags as defined by the configured encapsulation and tag rewrite configuration, and are treated as data frames (that is, they are forwarded transparently) if they have more than this number of tags.

In most cases, this behavior is as desired, since the CFM frames are then treated in exactly the same way as the data traffic flowing through the same service. However, in a scenario where multiple customer VLANs are multiplexed over a single multipoint provider service (for example, N:1 bundling), a different behavior might be desirable.

This figure shows an example of a network with multiple VLANS using CFM.

Figure 10: Service Provider Network With Multiple VLANs and CFM



This figure shows a provider's access network, where the S-VLAN tag is used as the service delimiter. PE1 faces the customer, and PE2 is at the edge of the access network facing the core. N:1 bundling is used, so the interface encapsulation matches a range of C-VLAN tags. This could potentially be the full range, resulting in all:1 bundling. There is also a use case where only a single C-VLAN is matched, but the S-VLAN is nevertheless used as the service delimiter—this is more in keeping with the IEEE model, but limits the provider to 4094 services.

CFM is used in this network with a MEP at each end of the access network, and MIPs on the boxes within the network (if it is native Ethernet). In the normal case, CFM frames are sent by the up MEP on PE1 with two VLAN tags, matching the customer data traffic. This means that at the core interfaces and at the MEP on PE2, the CFM frames are forwarded as if they were customer data traffic, since these interfaces match only on the S-VLAN tag. So, the CFM frames sent by the MEP on PE1 are not seen by any of the other MPs.

Flexible VLAN tagging changes the encapsulation for CFM frames that are sent and received at Up MEPs. Flexible VLAN tagging allows the frames to be sent from the MEP on PE1 with just the S-VLAN tag that represents the provider service. If this is done, the core interfaces will treat the frames as CFM frames and they will be seen by the MIPs and by the MEP on PE2. Likewise, the MEP on PE1 should handle received frames with only one tag, as this is what it will receive from the MEP on PE2.

To ensure that CFM packets from Up MEPs are routed to the appropriate paths successfully, tags may be set to a specific number in a domain service, using the **tags** command. Currently, tags can only be set to one (1).

CFM on MC-LAG

CFM on Multi-Chassis Link Aggregation Groups is supported on the Cisco ASR 9000 Series Router in the following typical network environment:

- The customer edge (CE) device is a dual-homed device that is connected to two provider edge (PE) point-of-attachment (POA) devices. However, the dual-homed device operates without awareness of connectivity to multiple PEs.
- The two points of attachment at the PE form a redundancy group (RG), with one POA functioning as the active POA, and the other as the standby POA for the dual-homed device link.
- As with typical failover scenarios, if a failure occurs with the active POA, the standby POA takes over to retain the dual-homed device’s connectivity to the network.

CFM on MC-LAG support can be qualified at two levels:

- CFM for the RG level—CFM context is per redundancy group and verifies connectivity for the entire RG.
- CFM for the POA level—CFM context is per point of attachment and verifies connectivity to a single POA.

Both levels of CFM support have certain restrictions and configuration guidelines that you must consider for successful implementation.

This section includes the following topics:

For more information about LAG and MC-LAG on the Cisco ASR 9000 Series Router, see the *Configuring Link Bundling* chapter in this guide.

RG-Level CFM

RG-level CFM is comprised of three areas of monitoring:

RG Downlink Monitoring

RG downlink monitoring uses CFM to verify connectivity between the dual-homed device and the RG.

To configure RG downlink monitoring, be sure that the following requirements are met:

- Down MEPs are configured on the bundle.
- Down MEPs on each POA are configured identically, using the same MEP ID and source MAC address.

This configuration has the following restrictions:

- The CCM loss time is greater than the failover time (typically 50 ms), due to the shortest CCM interval of 100 ms that is currently supported, which results in the shortest CCM loss time of 350 ms.

RG Uplink Monitoring

RG uplink monitoring uses CFM to verify connectivity from the active POA to the core.

To configure RG uplink monitoring, be sure that the following requirements are met:

- Up MEPs are configured on the bundle interface or bundle subinterface on each POA.
- Up MEPs on each POA are configured identically, using the same MEP ID and source MAC address.

End-to-End Service Monitoring

End-to-end service monitoring uses CFM to verify the end-to-end service between the dual-homed devices.

To configure end-to-end service monitoring, be sure that the following requirements are met:

- A down MEP is configured on the dual-homed device bundle interface or bundle subinterface.
- If optional MIPs are configured, then each POA is configured with a MIP on the bundle.
- Each POA can have a MIP on the uplink interface (if native Ethernet is used).
- The active and standby POA is configured identically.

This configuration has the following restrictions:

- The MIP on the standby POA will not respond to loopback or linktrace requests.

POA-Level CFM

POA-level monitoing uses CFM to verify connectivity between the dual-homed device and a single POA.

To configure POA-level CFM, be sure that the following requirements are met:

- Down MEPs are configured on bundle members only.

This configuration has the following restrictions:

- POA-level monitoring is not supported on uplinks between a single POA and the core.

Supported Features for CFM on MC-LAG

CFM on MC-LAG supports these CFM features:

- All existing IEEE 802.1ag and Y.1731 functionality on the Cisco ASR 9000 Series Router is supported on an MC-LAG RG.
- CFM maintenance points are supported on an MC-LAG interface. Maintenance points on a standby link are put into standby state.
- Maintenance points in standby state receive CFM messages, but do not send or reply to any CFM messages.
- When a MEP transitions from active to standby, all CCM defects and alarms are cleared.
- Standby MEPs record remote MEP errors and timeouts, but do not report faults. This means that remote MEPs and their errors will appear in **show** commands, but no logs, alarms, MIB traps, or EFD are triggered and AIS messages are not sent.
- When a MEP transitions from standby to active, any CCM defects previously detected while the MEP was in standby are reapplied and immediate actions are taken (logs, alarms, MIB traps, EFD, and so on).
- CFM on MC-LAG supports the same scale for bundle interfaces that is supported on the Cisco ASR 9000 Series Router.

Restrictions for CFM on MC-LAG

To support CFM on MC-LAG, you must consider these restrictions and requirements:

- The CFM configuration must be the same on both the active and standby POAs.
- The CFM state is not synchronized between the two POAs. This can lead to flapping of the interface line protocol state on POA failover if EFD is configured. Fault alarms might also be delayed if a failover occurs just after a fault has been detected.
- POA-level CFM monitoring is not supported on a native Ethernet uplink interface.
- MEPs on bundle interfaces at level 0 are not supported.
- Loopback, linktrace, and Y.1731 SLA operations cannot be started from a MEP in standby state.
- Checks for configuration consistency of MEP IDs to ensure identical configuration of POAs is not supported.
- Y.1731 SLA statistics can be split between the two POAs if a failover occurs. An external network management system would need to collect and collate these statistics from the two POAs.

CFM Software Acceleration

Cisco ASR 9000 Series Router provides bundle-offload configuration for CFM under global configuration mode. This configuration enables CFM software acceleration to support aggressive CCM intervals of 10ms and higher CFM scale on bundle interfaces. This feature is applicable only for cases when the bundle members are configured under the Cisco ASR 9000 Enhanced Ethernet Line Card or higher generation line cards.

CFM would not work if the bundle members are also present on the Cisco ASR 9000 Ethernet line Cards. The CFM software acceleration feature is turned off by default. The bundle-offload feature acts as a knob to switch the feature either ON or OFF.

Connectivity Fault Management Hardware Offload

Connectivity Fault Management (CFM) hardware offload feature allows service providers to implement connectivity monitoring at 3.3 ms and 10 ms for physical interfaces. This feature helps detecting network failure within short time and achieve high network availability for Layer 2.

This feature is supported on following ASR 9000 line cards:

- Cisco ASR 9000 Series 5th Generation High-Density Line Cards
- Cisco ASR 9000 Series 4th Generation QSFP28 based dense 100GE Line Cards
- Cisco ASR 9000 Series 3rd Generation Ethernet Line Cards

See Configuring Ethernet OAM.

Limitations

Consider these points before implementing CFM hardware offload:

- This feature supports only physical interfaces and subinterfaces.
- This feature can only be used for down MEPs.
- This feature supports a single offloaded local MEP per interface.

Configuring CFM Hardware Offload

Configuring CFM hardware offload feature involves these steps:

1. Configure a down MEP with continuity-check enabled at a supported offload interval of 3.3ms or 10ms

Note A Continuity Check Message (CCM) interval should have crosscheck configuration.

Example:

```
ethernet cfm
   domain dom1 level 1
    service ser1 down-meps
     continuity-check interval 3.3ms
     mep crosscheck
      mep-id 1
     !
```

2. Apply the down MEP on an interface

Example:

```
interface GigabitEthernet0/0/0/0.1 l2 transport
encapsulation dot1q 22
   ethernet cfm
   mep domain dom1 service ser1 mep-id 100
```

Verification

To verify the CFM hardware offload configuration, use the **show ethernet cfm peer meps interface** show command:

```
Router# show ethernet cfm peer meps interface tenGigE 0/0/0/0.1 detail
Thu Apr 16 22:59:01.886 IST
Domain lsp_down_mep_hw (level 3), Service lsp_hw_dn_1
Down MEP on TenGigE0/0/0/0.1 MEP-ID 100
================================================================================
Peer MEP-ID 1, MAC 00c1.6440.ed17
   CFM state: Ok, for 00:00:44
   Received CCM handling offloaded to hardware
   Port state: Up
   CCMs received: 0
     Out-of-sequence:             0
     Remote Defect received:      0
     Wrong level:                 0
     Cross-connect (wrong MAID):  0
     Wrong interval:              0
     Loop (our MAC received):     0
     Config (our ID received):    0
   Last CCM received:
     Level: 3, Version: 0, Interval: 3.3ms
     Sequence number: 4464, MEP-ID: 1
     MAID: String: lsp_down_mep_hw, String: lsp_hw_dn_1
     Chassis ID: Local: Z13-9006; Management address: 'Not specified'
     Port status: Up, Interface status: Up
```

```
Router# show ethernet cfm local meps interface tenGigE 0/0/0/0.1 verbose

Thu Apr 16 23:01:14.454 IST
Domain lsp_down_mep_hw (level 3), Service lsp_hw_dn_1
Down MEP on TenGigE0/0/0/0.1 MEP-ID 100
================================================================================
  Interface state: Up      MAC address: 10b3.d672.86a8
  Peer MEPs: 1 up, 0 with errors, 0 timed out (archived)
  Cross-check errors: 0 missing, 0 unexpected

  CCM generation enabled:  Yes, 3.3ms (Remote Defect detected: No)
                           CCM processing offloaded to hardware
  AIS generation enabled:  No
  Sending AIS:             No
  Receiving AIS:           No

  Packet        Sent      Received
  ------  ----------  ------------------------------------------------------------
  CCM          17157             0  (out of seq: 0)
```

The `show ethernet cfm local meps interface tenGigE 0/0/0/0.1 verbose` command displays the number of cross-check errors, and CCM packets sent to the peer. The command also confirms the CFM hardware offload feature is enabled with 3.3ms offload interval.

```
Router# show ethernet cfm summary
CFM Summary for 0/0/CPU0
========================

Domains                                 24
Services                             12236
Total CCM rate (pps)                  4111
Local Meps                            4004
  Operational                         4004
    Down MEPs                            3
```

```
    Up MEPs                              4001
    Offloaded                            4004
      3.3ms                                 1
      10ms                                  0
  Disabled (misconfiguration)               0
  Disabled (resource limit)                 0
  Disabled (operational error)              0
Peer MEPs                                4003
  Operational                            4003
    Defect detected                         0
    No defect detected                   4003
  Timed out                                 0
MIPs                                     4000
Interfaces                               4004
Bridge domains/Xconnects                 4401
Traceroute cache entries                    0
Traceroute cache replies                    0
CCM Learning database entries            4215
BNM Enabled Links                           0
ISSU Role                             Primary
```

The `show ethernet cfm summary` command shows the number of hardware offloaded sessions with 3.3ms and 10ms offload intervals.

Ethernet SLA

Customers require their service providers to conform to a Service Level Agreement (SLA). Consequently, service providers must be able to monitor the performance characteristics of their networks. Similarly, customers also want to monitor the performance characteristics of their networks. Cisco provides Y.1731 performance monitoring using the Cisco Ethernet SLA feature.

An SLA defines a set of criteria that guarantees a minimum level of service for customers using a service provider network. The criteria can cover many different areas, including latency, jitter, frame loss, and availability.

The Cisco Ethernet SLA feature conforms to these standards:

- IEEE 802.1ag
- ITU-T Y.1731

The Cisco Ethernet SLA feature provides the architecture to monitor a network at Layer 2. This architecture provides functions such as collecting, storing, displaying, and analyzing SLA statistics. These SLA statistics can be stored and displayed in various ways, so that statistical analysis can be performed.

Ethernet SLA provides the framework for performing the following major functions of performance monitoring:

- Sending probes consisting of one or more packets to measure performance

  Ethernet SLA provides a flexible mechanism for sending SLA probes to measure performance. Probes can consist of either CFM loopback or CFM delay measurement packets. Options are available to modify how often the packets are sent, and to specify the attributes of the probe packets such as the size and priority.

- Scheduling of operations consisting of periodic probes.

  A flexible mechanism is provided by Ethernet SLA to specify how often each probe should be executed, how long it should last, and when the first probe should start. Probes can be scheduled to run back-to-back to provide continuous measurements, or at a defined interval ranging from once a minute to once a week.

- Collecting and storing results.

  Ethernet SLA provides flexibility to specify which performance parameters should be collected and stored for each measurement probe. Performance parameters include frame delay and jitter (inter-frame delay variation). For each performance parameter, either each individual result can be stored, or the results can be aggregated by storing a counter of the number of results that fall within a particular range. A configurable amount of historical data can also be stored as well as the latest results.

- Analyzing and displaying results.

  Ethernet SLA performs some basic statistical analysis on the collected results, such as calculating the minimum, maximum, mean and standard deviation. It also records whether any of the probe packets were lost or misordered, or if there is any reason why the results may not be a true reflection of the performance (for example if a big jump in the local time-of-day clock was detected during the time when the measurements were being made).

Y.1731 Performance Monitoring

The ITU-T Y.1731 standard defines several mechanisms that can be used for performance monitoring in Carrier Ethernet networks. These are the measurement mechanisms that were defined in the standard:

Delay Measurement: This can be used to accurately measure frame delay by exchanging CFM frames containing timestamps, and to measure inter-frame delay variation (jitter) by comparing consecutive delay measurements. Delay Measurement messages can be used to perform these measurements:

- Round-trip time
- Round-trip Jitter
- One-way delay (both SD and DS)
- One-way jitter (both SD and DS)
- SLA Probe Packet corruption count
- Out of order SLA probe packet count
- SLA probe packet loss

Loss Measurement: Loss Measurement is an extension to the existing Ethernet SLA feature; it adds the functionality for loss measurement defined in the Y.1731 and G.8021 ITU-T standards. This is used to accurately measure the loss of data traffic, by exchanging CFM frames containing sent and received frame counters. It is also used to measure the availability of the network by tracking periods of high loss over time. Loss Measurement messages can be used to perform these measurements:

- Data packet loss
- SLA probe packet loss
- Out of order SLA Probe packet count
- SLA Probe Packet corruption count

Synthetic Loss Measurement: The loss measurement mechanism defined in Y.1731 can only be used in point-to-point networks, and only works when there is sufficient data traffic flowing. The difficulties with the Y.1731 Loss Measurement mechanism was recognized across the industry and hence an alternative mechanism has been defined and standardized for measuring loss.

This alternative mechanism does not measure the loss of the actual data traffic, but instead injects synthetic CFM frames and measures the loss of these synthetic frames. Statistical analysis can then be used to give an approximation to the loss of data traffic. This technique is called Synthetic Loss Measurement. This has been included in the latest version of the Y.1731 standard. Synthetic Loss Measurement messages can be used to perform these measurements:

- One-way loss (Source to Destination)
- One-way loss (Destination to Source)

Loopback: This is not primarily targetted at performance monitoring, but can be used to approximate round-trip delay and jitter, such as when the peer device does not support delay measurement. Loopback messages can be used to perform these measurements:

- Round-trip time
- Round-trip jitter
- SLA probe packet corruption count
- Out of order SLA probe packet count
- SLA probe packet loss

Loss Measurement Terminology

These are the commonly used terminology in Loss Measurement Mechanism:

- **Single-ended**: A mechanism where device A sends a measurement packet to device B, which in turn sends a response back to device A. All calculations and results are done on device A.
- **Dual-ended**: A mechanism where device A sends a measurement packet to device B, which does not send a response. All calculations and results are done on device B.
- **One-way**: A measurement of the performance of packets flowing in one direction, from device A to device B, or from device B to device A.
- **Two-way**: A measurement of the performance of packets flowing from device A to device B, and back to device A.
- **Forwards**: A one-way measurement from the initiator (device A) to the receiver, or responder (device B).
- **Backwards**: A one-way measurement from the responder (device B) to the initiator (device A).

Note Cisco IOS XR Software supports only single-ended LMM.

Loss Measurement Performance Attributes

These are two primary attributes that can be calculated based on loss measurements:

- Frame Loss Ratio (FLR)
- Availability

Frame Loss Ratio is the ratio of lost packets to sent packets:

(<num_sent > - <num_rcvd>)/(<num_sent>)

It is normally expressed as a percentage. The accuracy of the measurement depends majorly on the number of packets sent.

Availability is a complex attribute, typically measured over a long period of time, such as weeks or months. The intent of this performance attribute is to measure the proportion of time when there was prolonged high loss. Cisco IOS XR Software does not track the availability.

Limitations of Data Loss Measurement

1. Data loss measurement cannot be used in a multipoint service; it can only be used in a peer-to-peer service.
2. As a Loss Measurement Reply (LMR) contains no sequence IDs, the only field, which can be used to distinguish to which probe a given LMR corresponds, is the priority level. Also, the priority level is the only field that can determine whether the LMR is in response to an on-demand or proactive operation. This limits the number of Loss Measurement probes that can be active at a time for each local MEP to 16.
3. As loss measurements are made on a per-priority class basis, QoS policies, which alter the priority of packets processed by the network element, or re-order packets can affect the accuracy of the calculations. For the highest accuracy, packets must be counted after any QoS policies have been applied.
4. The accuracy of data loss measurement is highly dependent on the number of data packets that are sent. If the volume of data traffic is low, errors with the packet counts might be magnified. If there is no data traffic flowing, no loss measurement performance attributes can be calculated. If aggregate measurements are taken, then only 2 probes can be active at the same time: one proactive and one on-demand.
5. The accuracy of data loss measurement is highly dependent on the accuracy of platform-specific packet counters. Due to hardware limitations, it may not be possible to achieve completely accurate packet counters, especially if QoS policies are applied to the packets being counted.
6. Performing data loss measurement can have an impact on the forwarding performance of network elements; this is because of the need to count, as well as forward the packets.
7. Before starting any LMM probes,it is necessary to allocate packet counters for use with LMM on both ends (assuming both ends are running Cisco IOS XR Software).

Ethernet SLA Concepts

To successfully configure the Cisco Ethernet SLA feature, you should understand the following concepts:

Loss Measurement Terminology

A *statistic* in Ethernet SLA is a single performance parameter. These statistics can be measured by Ethernet SLA:

- Round-trip delay
- Round-trip jitter
- One-way delay from source to destination
- One-way jitter from source to destination

- One-way frame loss from source to destination
- One-way delay from destination to source
- One-way jitter from destination to source
- One-way frame loss from destination to source

Note Not all statistics can be measured by all types of packet. For example, one-way statistics cannot be measured when using CFM loopback packets.

Ethernet SLA Measurement Packet

An Ethernet SLA *measurement packet* is a single protocol message and corresponding reply that is sent on the network for the purpose of making SLA measurements. These types of measurement packet are supported:

- CFM Delay Measurement (Y.1731 DMM/DMR packets)—CFM delay measurement packets contain timestamps within the packet data that can be used for accurate measurement of frame delay and jitter. These packets can be used to measure round-trip or one-way statistics; however, the size of the DMM/DMR packets cannot be modified.

Note From Cisco IOS XR Release 4.3.x onwards, you can configure the Ethernet SLA profile to use Y.1731 DMM v1 frames. The restriction of 150 configured Ethernet SLA operations for each CFM MEP is removed not only for profiles using DMM frames, but also for profiles using the other supported Y.1731 frame types, such as loopback measurement and synthetic loss measurement. For interoperability purposes, it is still possible to configure operations to use DMM v0 frames. This is done by specifying a type of **cfm-delay-measurement-v0** on the **ethernet SLA profile** command. The limit of 150 configured operations for each CFM MEP still applies in this case.

- CFM loopback (LBM/LBR)—CFM loopback packets are less accurate, but can be used if the peer device does not support DMM/DMR packets. Only round-trip statistics can be measured because these packets do not contain timestamps. However, loopback packets can be padded, so measurements can be made using frames of a specific size.
- CFM Synthetic Loss Measurement (Y.1731 SLM/SLR packets)—SLM packets contain two sequence numbers; one written by the initiator into the SLM and copied by the responder into the SLR, and the other allocated by the responder and written into the SLR. These are refered to as the source-to-destination (sd) sequence number and the destination-to-source (ds) sequence number respectively.

Note Because SLM is a statistical sampling technique, there may be some variance of the measured value around the actual loss value. Also, the accuracy of the measurement is improved by using more SLM packets for each FLR calculation.

- CFM Loss Measurement (Y.1731 LMM/LMR packets)— As LMMs and LMRs contain no sequence ID, there is a limited set of data that can be used to distinguish different Loss Measurement operations, limiting the number of concurrent operations for each MEP.

Ethernet SLA Sample

A *sample* is a single result—a number—that relates to a given statistic. For some statistics such as round-trip delay, a sample can be measured using a single measurement packet. For other statistics such as jitter, obtaining a sample requires two measurement packets.

Ethernet SLA Probe

A *probe* is a sequence of measurement packets used to gather SLA samples for a specific set of statistics. The measurement packets in a probe are of a specific type (for example, CFM delay measurement or CFM loopback) and have specific attributes, such as the frame size and priority.

Note A single probe can collect data for different statistics at the same time, using the same measurement packets (for example, one-way delay and round-trip jitter).

Ethernet SLA Burst

Within a probe, measurement packets can either be sent individually, or in bursts. A *burst* contains two or more packets sent within a short interval apart. Each burst can last up to one minute, and bursts can follow each other immediately to provide continuous measurement within the probe.

For statistics that require two measurement packets for each sample (such as jitter), samples are only calculated based on measurement packets in the same burst. For all statistics, it is more efficient to use bursts than to send individual packets.

Note If bursts are configured back to back, so as to cause a continuous and uninterrupted flow of SLA packets, then packets at the end of one burst and the start of the next are used in Loss Measurement calculations.

Ethernet SLA Schedule

An Ethernet SLA *schedule* describes how often probes are sent, how long each probe lasts, and at what time the first probe starts.

Note If probes are scheduled back to back, so as to cause a continuous and uninterrupted flow of SLA packets, then packets at the end of one probe and the start of the next are used in Loss Measurement calculations.

Ethernet SLA Bucket

For a particular statistic, a *bucket* is a collection of results that were gathered during a particular period of time. All of the samples for measurements that were initiated during the period of time represented by a bucket are stored in that bucket. Buckets allow results from different periods of time to be compared (for example, peak traffic to off-peak traffic).

By default, a separate bucket is created for each probe; that is, the bucket represents the period of time starting at the same time as the probe started, and continuing for the duration of the probe. The bucket will therefore contain all the results relating to measurements made by that probe.

Ethernet SLA Aggregation Bin

Rather than storing each sample separately within a bucket, an alternative is to aggregate the samples into bins. An *aggregation bin* is a range of sample values, and contains a counter of the number of samples that were received that fall within that range. The set of bins forms a histogram. When aggregation is enabled, each bucket contains a separate set of bins. See this figure.

Ethernet SLA Operation Profile

An *operation profile* is a configuration entity that defines the following aspects of an operation:

- What packet types to send and in what quantities (probe and burst configuration)
- What statistics to measure, and how to aggregate them
- When to schedule the probes

An operation profile by itself does not cause any packets to be sent or statistics collected, but is used to create operation instances.

Ethernet SLA Operation

An *operation* is an instance of a given operation profile that is actively collecting performance data. Operation instances are created by associating an operation profile with a given source (an interface and MEP) and with a given destination (a MEP ID or MAC address). Operation instances exist for as long as the configuration is applied, and they run for an indefinite duration on an ongoing basis.

Ethernet SLA On-Demand Operation

An *on-demand operation* is a method of Ethernet SLA operation that can be run on an as-needed basis for a specific and finite period of time. This can be useful in situations such as when you are starting a new service or modifying the parameters for a service to verify the impact of the changes, or if you want to run a more detailed probe when a problem is detected by an ongoing scheduled operation.

On-demand operations do not use profiles and have a finite duration. The statistics that are collected are discarded after a finite time after the operation completes (two weeks), or when you manually clear them.

On-demand operations are not persistent so they are lost during certain events such as a card reload or Minimal Disruptive Restart (MDR).

Statistics Measurement and Ethernet SLA Operations Overview

Ethernet SLA statistics measurement for network performance is performed by sending packets and storing data metrics such as:

- Round-trip delay time—The time for a packet to travel from source to destination and back to source again.
- Round-trip jitter—The variance in round-trip delay time (latency).
- One-way delay and jitter—The router also supports measurement of one-way delay or jitter from source to destination, or from destination to source.
- One-way frame loss—The router also supports measurement of one-way frame loss from source to destination, or from destination to source.

In addition to these metrics, these statistics are also kept for SLA probe packets:

- Packet loss count
- Packet corruption event
- Out-of-order event
- Frame Loss Ratio (FLR)

Counters for packet loss, corruption and out-of-order packets are kept for each bucket, and in each case, a percentage of the total number of samples for that bucket is reported (for example, 4% packet corruption). For delay, jitter, and loss statistics, the minimum, maximum, mean and standard deviation for the whole bucket are reported, as well as the individual samples or aggregated bins. Also, the overall FLR for the bucket, and individual FLR measurements or aggregated bins are reported for synthetic loss measurement statistics. The packet loss count is the overall number of measurement packets lost in either direction and the one-way FLR measures the loss in each direction separately.

When aggregation is enabled using the **aggregate** command, bins are created to store a count of the samples that fall within a certain value range, which is set by the **width** keyword. Only a counter of the number of results that fall within the range for each bin is stored. This uses less memory than storing individual results. When aggregation is not used, each sample is stored separately, which can provide a more accurate statistics analysis for the operation, but it is highly memory-intensive due to the independent storage of each sample.

A bucket represents a time period during which statistics are collected. All the results received during that time period are recorded in the corresponding bucket. If aggregation is enabled, each bucket has its own set of bins and counters, and only results relating to the measurements initiated during the time period represented by the bucket are included in those counters.

By default, there is a separate bucket for each probe. The time period is determined by how long the probe lasts (configured by the **probe**, **send (SLA)**, and **schedule (SLA)** commands).You can modify the size of buckets so that you can have more buckets per probe or fewer buckets per probe (less buckets allows the results from multiple probes to be included in the same bucket). Changing the size of the buckets for a given metric clears all stored data for that metric. All existing buckets are deleted and new buckets are created.

Scheduled SLA operation profiles run indefinitely, according to a configured schedule, and the statistics that are collected are stored in a rolling buffer, where data in the oldest bucket is discarded when a new bucket needs to be recorded.

Frame Loss Ratio (FLR) is a primary attribute that can be calculated based on loss measurements. FLR is defined by the ratio of lost packets to sent packets and expressed as a percentage value. FLR is measured in each direction (source to destination and destination to source) separately. Availability is an attribute, that is typically measured over a long period of time, such as weeks or months. The intent is to measure the proportion of time when there was prolonged high loss.

Configuration Overview of Scheduled Ethernet SLA Operations

When you configure a scheduled Ethernet SLA operation, you perform these basic steps:

1. Configure global profiles to define how packets are sent in each probe, how the probes are scheduled, and how the results are stored.
2. Configure operations from a specific local MEP to a specific peer MEP using these profiles.

Note Certain Ethernet SLA configurations use large amounts of memory which can affect the performance of other features on the system. For more information, see the Configuring Ethernet SLA.

Bit Error Rate

In network transmission, data streaming over communication channels is susceptible to unplanned alterations during transmission. Such alterations are due to noise, interference, or synchronization errors. The number of bits thus received with alterations is measured as the number of bit errors.

Bit Error Rate (BER) is the number of bit errors per unit time or time window. For example, consider a scenario where the bit rate reaching the receiver is 10 bits per second, and the bit error is 1 bit per second. In this example, the BER is bit errors/unit time or time window = 1 bit/second.

Using this feature, you can test cables and diagnose signal problems in the field. You can display and analyze the total number of error bits transmitted and the total received on the link. Your router supports BER on 10/40/100 GE interfaces.

The error range measurement that your router supports is 10E-8 through 10E-12 bits, where E = *10^. Thus, the error range is from:

10*10^ -8 = 10 x 0.00000001 = 0.0000001 bits

through

10*10^ -12 = 10 x 0.000000000001 = 0.00000000001 bits

Bit errors usually occur because of:

- Faulty or bad cables
- Loose cable connections at one or both ends

How is Bit Error Rate Measured?

BER algorithm polls the hardware counters periodically for bit errors, every 500ms.

For 40 GE and 100GE interfaces, your router uses a physical coding sublayer (PCS) bit interleaved parity (BIP) error counter.

For 10 GE interfaces, your router employs a sync header error counter. (BIP counters aren’t supported for 10GE interfaces.)

What are Bit Error Rate Error States and Thresholds?

BER has the following error conditions for which you must configure threshold values at the interface:

- Signal Degradation (SD): there’s a reduction in the signal quality but no loss of service, referred to as 'graceful error'.
- Signal Failure (SF): there's a loss of service because of a link-state change, referred to as 'catastrophic error'. The SF threshold state is enabled by default.

A switch uses the BER threshold value to detect an increased error rate before performance degradation seriously affects traffic. If the polling indicates the reaching of the error threshold value:

- For SD BER: the console generates an IOS message.
- For SF BER: the console generates an IOS message. Plus, you can bring down the interface transmission at the device under test (DUT) end.

Sliding Window for Polling

BER employs the concept of a sliding window to measure bit performance while polling happens in a small-length sequence of several windows. Here, 'window' refers to the BIP period or duration defined for different threshold levels. Consider a scenario where the BIP period is 2.5 seconds and the software polls the hardware counter every 500 ms. In this example, the 2.5 seconds BIP period is complete after five polls, and the window completely deploys. For the next round of polling, the window slides to the following sequence, thus ensuring better error performance while consuming lesser memory.

Alarm Raise

If errors above the configured threshold accumulate in the first poll, an alarm is raised right away instead of waiting for the completion of the BIP period. For example, if there are errors above the threshold value in the first poll of 500 ms, an alarm is raised immediately and not after completing 2.5 seconds (five polls) of the BIP period.

Alarm Clearance

The SD and SF alarm clearance is automatic once the error value is below a certain threshold level. Your router uses the configured error threshold value to measure the errors and generates IOS messages at that threshold.

Your router waits till the last poll of window deployment before clearing the alarm. The alarm is cleared as soon as the error value goes below the configured threshold value. This ensures that no new errors accumulate during the last poll of the completed window, which might keep the error count above the threshold.

Configure BER

To configure BER thresholds:

1. Enter the configuration mode for your interface.
2. Enable the Signal Degrade Bit Error Rate (SD-BER) on the interface.

Note SD-BER is disabled by default.

3. Configure the SD-BER threshold.
4. Configure the Signal Fail Bit Error Rate (SF-BER) threshold.

Note SF-BER is enabled by default.

5. Enable remote fault signaling when SF BER is triggered.

Note Remote signaling for SF BER is disabled by default.

```
Router#config
Router(config)#int TenGigE 0/1/0/3
/*Enable SD-BER*/
Router(config-if)#report sd-ber
/*Configure SD-BER threshold*/
Router(config-if)#threshold sd-ber 12
/*Configure SF-BER threshold*/
Router(config-if)#threshold sf-ber 8
Router(config-if)#commit
Router(config-if)#exit
```

Running Configuration

```
int TenGigE 0/1/0/3
!
 report sd-ber
!
 threshold sd-ber 12
!
 threshold sf-ber 8
!
!
```

Verification

Run the **show controllers <interface> all** command to verify the BER default value as well as the configured threshold values.

```
BER monitoring:
Signal Degrade: 1e-11 (report-alarm)
Signal Fail: 1e-9 (report-alarm, signal-rf)
Current SD BER: 0
Current SF BER: 0

BER-SD Threshold: 1e-12
BER-SD Report: Enabled
BER-SF Threshold: 1e-8
BER-SF Report: Not configured (Enabled)
```

Cyclic Redundancy Check

The Cyclic Redundancy Check (CRC) based Bit Error Ratio (BER) is an active measure of the error rate in a communication system that utilizes CRC as an error detection method. CRC is a widely adopted error-detection technique that ensures the integrity of data transmissions. It involves appending a fixed number of check bits to the transmitted data, which are then utilized to identify any errors that may occur during the transmission process.

The CRC based BER calculates the number of errors in a received message, divided by the total number of transmitted bits. This measurement allows you to evaluate the quality of the communication system and identify any potential issues that require attention. A low BER indicates a high-quality system with minimal errors, while a high BER signifies a higher error rate and potential concerns with the communication system.

BER represents the number of bit errors per unit of time. The BER ratio denotes the number of Cyclic Redundancy Check (CRC) errors divided by the total number of transferred bits during a specific time interval.

Furthermore, BER utilizes CRC for error detection within a network, enabling you to promptly identify and address faulty links.

The CRC based BER feature is available on the following line cards: [List line cards here].

- A9K-24X10GE-1G-SE
- A9K-24X10GE-1G-TR
- A9K-48X10GE-1G-SE
- A9K-48X10GE-1G-TR
- A99-48X10GE-1G-SE
- A99-48X10GE-1G-TR

Configure CRC BER

```
Router#config
Router(config)#int TenGigE 0/1/0/3
/*Enable CRC BER
Router(config-if)#report crc-ber
/*Enable SD-BER*/
Router(config-if)#report sd-ber
/*Configure SD-BER threshold*/
Router(config-if)#threshold sd-ber 12
/*Configure SF-BER threshold*/
Router(config-if)#threshold sf-ber 8
/*Enable crc-ber autorecovery*/
Router(config-if)#crc-ber auto-recover 2
Router(config-if)#commit
Router(config-if)#exit
```

Running Configuration

```
interface TenGigE0/1/0/3
 ipv4 address 11.1.13.1 255.255.255.0
 report crc-ber    ---- > mandatory config to report crc-ber
 report sd-ber     ----- > To report sd-ber
 threshold sd-ber 12  --- > sd-ber threshold set to 12
 threshold sf-ber 8   ---- > sf-ber threshold set to 8
 crc-ber auto-recover 2     ---- > ber is cleared within configured time
```

Verification

Run the **show controllers <interface> all** command to verify the BER default value as well as the configured threshold values.

```
RP/0/RSP0/CPU0:ios#show controllers tenGigE0/1/0/3 all | inc BER
BER-SD Threshold: 1e-6
    BER-SD Report: Enabled
    BER-SF Threshold: 1e-7
    BER-SF Report: Not configured (Enabled)
    BER-CRC Report: Enabled
```

Associated Commands

- report crc-ber
- crc-ber auto-recover

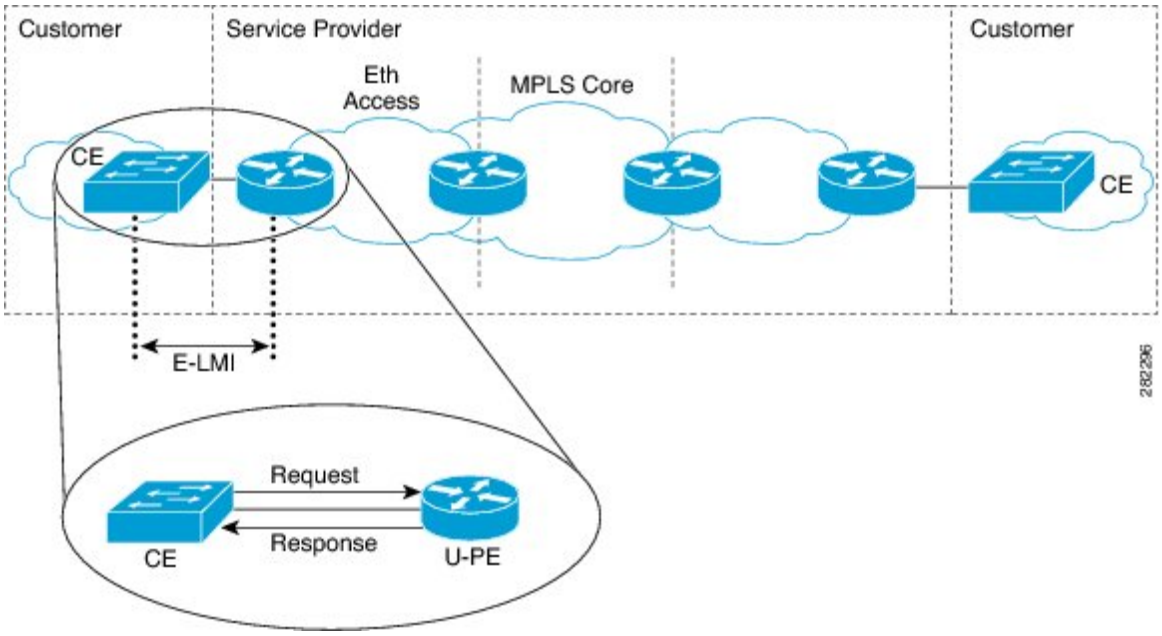
- report sd-ber
- report sf-ber disable
- threshold sd-ber
- threshold sf-ber

Ethernet LMI

The Cisco ASR 9000 Series Router supports the Ethernet Local Management Interface (E-LMI) protocol as defined by the *Metro Ethernet Forum, Technical Specification MEF 16, Ethernet Local Management Interface (E-LMI), January 2006* standard.

E-LMI runs on the link between the customer-edge (CE) device and the provider-edge (PE) device, or User Network Interface (UNI), and provides a way for the CE device to auto-configure or monitor the services offered by the PE device (see this figure).

Figure 11: E-LMI Communication on CE-to-PE Link



E-LMI is an asymmetric protocol whose basic operation involves the User-facing PE (uPE) device providing connectivity status and configuration parameters to the CE using STATUS messages in response to STATUS ENQUIRY messages sent by the CE to the uPE.

E-LMI Messaging

The E-LMI protocol as defined by the MEF 16 standard, defines the use of only two message types—STATUS ENQUIRY and STATUS.

These E-LMI messages consist of required and optional fields called information elements, and all information elements are associated with assigned identifiers. All messages contain the Protocol Version, Message Type,

and Report Type information elements, followed by optional information elements and sub-information elements.

E-LMI messages are encapsulated in 46- to 1500-byte Ethernet frames, which are based on the IEEE 802.3 untagged MAC-frame format. E-LMI frames consist of the following fields:

- Destination address (6 bytes)—Uses a standard MAC address of 01:80:C2:00:00:07.
- Source address (6 bytes)—MAC address of the sending device or port.
- E-LMI Ethertype (2 bytes)—Uses 88-EE.
- E-LMI PDU (46–1500 bytes)—Data plus 0x00 padding as needed to fulfill minimum 46-byte length.
- CRC (4 bytes)—Cyclic Redundancy Check for error detection.

For more details about E-LMI messages and their supported information elements, refer to the Metro Ethernet Forum, Technical Specification MEF 16, Ethernet Local Management Interface (E-LMI), January 2006.

Cisco-Proprietary Remote UNI Details Information Element

The E-LMI MEF 16 specification does not define a way to send proprietary information.

To provide additional information within the E-LMI protocol, the Cisco IOS XR software implements a Cisco-proprietary information element called Remote UNI Details to send information to the CE about remote UNI names and states. This information element implements what is currently an unused identifier from the E-LMI MEF 16 specification.

To ensure compatibility for future implementations of E-LMI should this identifier ever be implemented in the standard protocol, or for another reason, you can disable transmission of the Remote UNI information element using the **extension remote-uni disable** command.

E-LMI Operation

The basic operation of E-LMI consists of a CE device sending periodic STATUS ENQUIRY messages to the PE device, followed by mandatory STATUS message responses by the PE device that contain the requested information. Sequence numbers are used to correlate STATUS ENQUIRY and STATUS messages between the CE and PE.

The CE sends the following two forms of STATUS ENQUIRY messages called Report Types:

- E-LMI Check—Verifies a Data Instance (DI) number with the PE to confirm that the CE has the latest E-LMI information.
- Full Status—Requests information from the PE about the UNI and all EVCs.

The CE device uses a polling timer to track sending of STATUS ENQUIRY messages, while the PE device can optionally use a Polling Verification Timer (PVT), which specifies the allowable time between transmission of the PE's STATUS message and receipt of a STATUS ENQUIRY from the CE device before recording an error.

In addition to the periodic STATUS ENQUIRY/STATUS message sequence for the exchange of E-LMI information, the PE device also can send asynchronous STATUS messages to the CE device to communicate changes in EVC status as soon as they occur and without any prompt by the CE device to send that information.

Both the CE and PE devices use a status counter (N393) to determine the local operational status of E-LMI by tracking consecutive errors received before declaring a change in E-LMI protocol status.

Supported E-LMI PE Functions on the Cisco ASR 9000 Series Router

The Cisco ASR 9000 Series Router serves as the PE device for E-LMI on a MEN, and supports the following PE functions:

- Supports the E-LMI protocol on Ethernet physical interfaces that are configured with Layer 2 subinterfaces as Ethernet Flow Points (EFPs), which serve as the EVCs about which the physical interface reports status to the CE. The Cisco IOS XR software does not support a specific manageability context for an Ethernet Virtual Connection (EVC).

Note For E-LMI on the Cisco ASR 9000 Series Router, the term EVC in this documentation refers to a Layer 2 subinterface/EFP.

- Provides the ability to configure the following E-LMI options defined in the MEF 16 specification:
  - T392 Polling Verification Timer (PVT)
  - N393 Status Counter
- Sends notification of the addition and deletion of an EVC.
- Sends notification of the availability (active) or unavailability (inactive, partially active) status of a configured EVC.
- Sends notification of the local UNI name.
- Sends notification of remote UNI names and states using the Cisco-proprietary Remote UNI Details information element, and the ability to disable the Cisco-proprietary Remote UNI information element.
- Sends information about UNI and EVC attributes to the CE (to allow the CE to auto-configure these attributes), including:
  - CE-VLAN to EVC Map
  - CE-VLAN Map Type (Bundling, All-to-one Bundling, Service Multiplexing)
  - Service Type (point-to-point or multipoint)
- Uses CFM Up MEPs to retrieve the EVC state, EVC Service Type, and remote UNI details.
- Provides the ability to retrieve the per-interface operational state of the protocol (including all the information currently being communicated by the protocol to the CE) using the command-line interface (CLI) or Extensible Markup Language (XML) interface.
- Supports up to 80 E-LMI sessions per linecard (one per physical interface).
- Supports up to 32000 EVCs total per linecard for all physical interfaces enabled for E-LMI.

Unsupported E-LMI Functions

These areas of E-LMI are not supported on the Cisco ASR 9000 Series Router:

- CE functions

Unidirectional Link Detection Protocol

Unidirectional Link Detection (UDLD) is a single-hop physical link protocol for monitoring an ethernet link, including both point-to-point and shared media links. This is a Cisco-proprietary protocol to detect link problems, which are not detected at the physical link layer. This protocol is specifically targeted at possible wiring errors, when using unbundled fiber links, where there can be a mismatch between the transmitting and receiving connections of a port.

UDLD Operation

UDLD works by exchanging protocol packets between the neighboring devices. In order for UDLD to work, both devices on the link must support UDLD and have it enabled on respective ports.

UDLD sends an initial PROBE message on the ports where it is configured. Once UDLD receives a PROBE message, it sends periodic ECHO (hello) messages. Both messages identify the sender and its port, and also contain some information about the operating parameters of the protocol on that port. They also contain the device and port identifiers for any neighbor devices that the local device has heard from, on the port. Similarly, each device gets to know where it is connected and where its neighbors are connected.

This information can then be used to detect faults and miswiring conditions. The protocol operates an aging mechanism by means of which information from neighbors that is not periodically refreshed is eventually timed out. This mechanism can also be used for fault detection.

A FLUSH message is used to indicate that UDLD is disabled on a port, which causes the peers to remove the local device from their neighbor cache, to prevent it from being aged out.

If a problem is detected, UDLD disables the affected interface and also notifies the user. This is to avoid further network problems beyond traffic loss, such as loops which are not detected or prevented by STP.

Types of Fault Detection

UDLD can detect these types of faults:

- Transmit faults — These are cases where there has been a failure in transmitting packets from the local port to the peer device, but packets continue to be received from the peer. These faults are caused by failure of the physical link (where notification at layer 1 of unidirectional link faults is not supported by the media) as well as packet path faults on the local or peer device.
- Miswiring faults — These are cases where the receiving and transmitting sides of a port on the local device are connected to different peer ports (on the same device or on different devices). This can occur when using unbundled fibers to connect fiber optic ports.
- Loopback faults — These are cases where the receiving and transmitting sides of a port are connected to each other, creating a loopback condition. This can be an intentional mode of operation, for certain types of testing, but UDLD must not be used in these cases.
- Receive faults — The protocol includes a heartbeat that is transmitted at a negotiated periodic interval to the peer device. Missed heartbeats can therefore be used to detect failures on the receiving side of the link (where they do not result in interface state changes). These could be caused by a unidirectional link with a failure only affecting the receiving side, or by a link which has developed a bidirectional fault. This detection depends on reliable, regular packet transmission by the peer device. For this reason, the UDLD protocol has two (configurable) modes of operation which determine the behavior on a heartbeat timeout. These modes are described in the section UDLD Modes of Operation.

UDLD Modes of Operation

UDLD can operate in these modes:

- **Normal mode**: In this mode, if a Receive Fault is detected, the user is informed and no further action is taken.
- **Aggressive mode**: In this mode, if a Receive Fault is detected, the user is informed and the affected port is disabled.

UDLD Aging Mechanism

This is a scenario that happens in a receive fault condition. Aging of UDLD information happens when the port that runs UDLD does not receive UDLD packets from the neighbor port for duration of hold time. The hold time for the port is dictated by the remote port and depends on the message interval at the remote side. The shorter the message interval, the shorter is the hold time and the faster the detection. The hold time is three times the message interval in Cisco IOS XR Software.

UDLD information can age out due to the high error rate on the port caused by some physical issue or duplex mismatch. Such packet drop does not mean that the link is unidirectional and UDLD in normal mode does not disable such link.

It is important to choose the right message interval in order to ensure proper detection time. The message interval should be fast enough to detect the unidirectional link before the forwarding loop is created. The default message interval is 60 seconds. The detection time is equal to approximately three times the message interval. So, when using default UDLD timers, UDLD does not time out the link faster than the STP aging time.

State Machines

UDLD uses two types of finite state machines (FSMs), generally referred as state machines. The Main FSM deals with all the phases of operation of the protocol while the Detection FSM handles only the phases that determine the status of a port.

Main FSM

The Main FSM can be in one of these states:

- **Init**: Protocol is initializing.
- **UDLD inactive**: Port is down or UDLD is disabled.
- **Linkup**: Port is up and running, and UDLD is in the process of detecting a neighbor.
- **Detection**: A hello message from a new neighbor has been received and the Detection FSM is running to determine the status of the port.
- **Advertisement**: The Detection FSM has run and concluded that the port is operating correctly, periodic hellos will continue to be sent and hellos from neighbors monitored.
- **Port shutdown**: The Detection FSM detected a fault, or all neighbors were timed out in Aggressive mode, and the port has been disabled as a result.

Detection FSM

The Detection FSM can be in one of these states:

- **Unknown**: Detection has not yet been performed or UDLD has been disabled.
- **Unidirectional detected**: A unidirectional link condition has been detected because a neighbor does not see the local device, the port will be disabled.
- **Tx/Rx loop**: A loopback condition has been detected by receiving a TLV with the ports own identifiers, the port will be disabled.
- **Neighbor mismatch**: A miswiring condition has been detected in which a neighbor can identify other devices than those the local device can see and the port will be disabled.
- **Bidirectional detected**: UDLD hello messages are exchanged successfully in both directions, the port is operating correctly.

Ethernet Data Plane Loopback

The Ethernet Data Plane Loopback feature allows you to test services and throughput of an Ethernet port or a device using a test generator. You can verify the maximum rate of frame transmission with no frame loss. This feature allows bidirectional throughput measurement, and on-demand or out-of-service (intrusive) operation during service turn-ups. This feature can be used for testing during service turn-ups and troubleshooting of services after a turn-up.

If you need to test a service while it is live, you can do this without disrupting any of the live data traffic. To achieve this, you can use test traffic that differs from live data traffic. For example, the traffic from a test generator can contain the source MAC address of the test generator, or test traffic may be assigned a particular Class of Service (CoS). Irrespective of the method used, the device looping back the traffic must be able to filter out the test traffic and leave the data traffic untouched.

Note Configuring Ethernet Data Plane Loopback on a device does not indicate the start of an actual session.

Features Supported for Ethernet Data Plane Loopback

The support that the Ethernet Data Plane Loopback feature provides is:

- Locally-enabled Ethernet Data Plane Loopback on all Ethernet interface types, such as physical and bundle interfaces and sub-interfaces.
- In the case of Layer 2 interfaces, support for these types of looping back of traffic:
  - External loopback – All traffic received on the ingress interface is blindly sent out of the egress interface.
  - Internal loopback – All traffic received on the egress interface is blindly injected into the ingress interface.
- In the case of Layer 3 interfaces, only external loopback is supported.
- When a Bundle interface is placed into loopback, traffic on all bundle link members are looped back.

- MAC address must always be swapped on looped-back traffic.
- Allows the application of multiple filters to loopback only a subset of traffic received by an interface and only drop the corresponding reverse-direction traffic.
- Provides an option to specify a time period after which the loopback is automatically terminated.
- Supports at least 100 simultaneous loopback sessions across the system.

Limitations of Ethernet Data Plane Loopback

These are the limitations of Ethernet Data Plane Loopback (EDPL):

- Layer 3 interfaces including pseudowires are not supported in internal EDPL.
- The first generation Cisco ASR 9000 Ethernet Line Cards are not supported.
- The fifth generation Cisco ASR 9000 series high density ethernet line cards do not support internal EDPL
- Virtual interfaces such as BVI are not supported.
- Filtering based on LLC-OUI is not supported.
- A maximum of 50 simultaneous loopback sessions are supported for each Network Processor on the linecard.
- LAG bundles that are member of Satellite nV interface over bundle inter-chassis link (also known as LAG over LAG bundles) are not supported.

Configuring Ethernet Data Plane Loopback

Perform these steps to configure Ethernet Data Plane Loopback.

- Configure Ethernet Data Plane Loopback
- Start an Ethernet Data Plane Loopback Session

/ * Enable the privileged EXEC mode. Enter your password if prompted and then configure the terminal*/

```
Router# enable
Router# configure
```

/* Specify the interface on which you want to enable EDPL and specify if the ethernet loopback permit must be internal or external. */

```
Router(config)# interface
TenGigE 0/1/0/0
Router(config-if-srv)# ethernet loopback permit external
or
Router(config-if-srv)# ethernet loopback permit internal
Router# end
Router(config-if-srv)# commit
```

/* Start an EDPL session */

```
RP/0/RSP0/CPU0:router#ethernet loopback start local interface TenGigE0/0/0/29 external
destination mac-address 008a.9678.781c
 Router#ethernet loopback start local interface  TenGigE0/0$
```

```
LC/0/0/CPU0:Jan 11 14:27:57.086 IST: EDPL-MA[354]: %L2-ETH_LB-6-SESSION_STARTED : Session
4 on interface TenGigE0/0/0/29 has successfully started.
Session on interface TenGigE0/0/0/29 successfully created with ID 4.
```

Configures ethernet loopback externally or internally on an interface. External loopback allows loopback of traffic from wire. Internal loopback allows loopback of traffic from the bridge domain.

When you enter the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- When you issue the **end** command, the system prompts you to commit changes:

  ```
  Uncommitted changes found, commit them before exiting(yes/no/cancel)?
  [cancel]:
  ```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Running Configuration

This example shows external loopback on the TenGig Ethernet 0/0/0/29 interface:

```
interface TenGigE0/0/0/29
ethernet loopback
  permit external
  permit internal
!
!
```

```
Router# ethernet loopback start local interface  TenGigE0/0/0/29 external  destination
mac-address 008a.9678.781c
 Router#ethernet loopback start local interface  TenGigE0/0$
LC/0/0/CPU0:Jan 11 14:27:57.086 IST: EDPL-MA[354]: %L2-ETH_LB-6-SESSION_STARTED : Session
4 on interface TenGigE0/0/0/29 has successfully started.
Session on interface TenGigE0/0/0/29 successfully created with ID 4.
```

Verification

Verify that ethernet loopback is active on TenGigE0/0/0/29 interface.

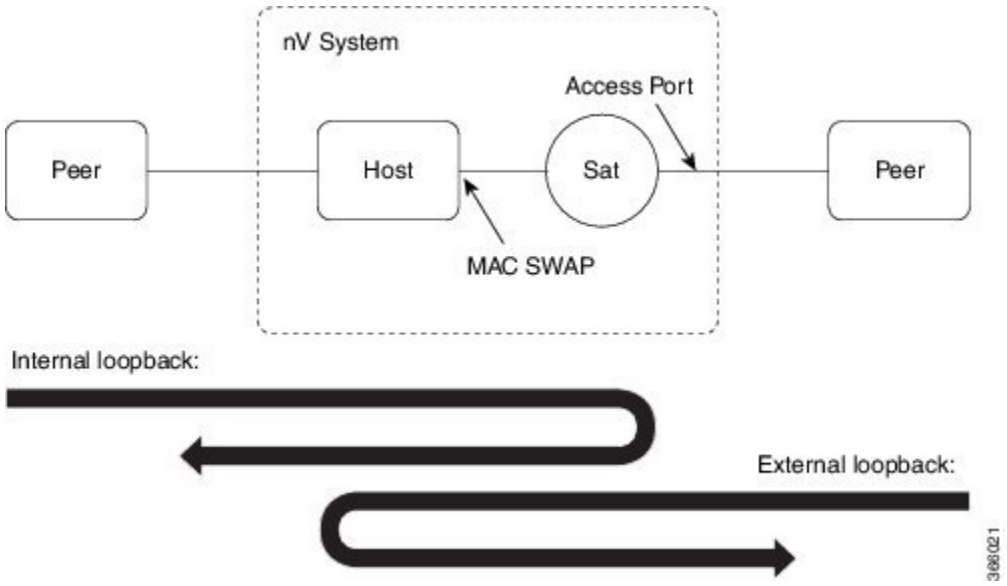
```
Router:ABC#show ethernet loopback permitted
Wed Jan 11 14:29:03.503 IST
Local Loopback
Interface                     Direction
-------------------------------------------------
TenGigE0/0/0/29               External, Internal

Latching Loopback
Interface                     Direction
```

```
-----------------------------------------------

Loopback Controller
Interface
-----------------------------------------------

Router:ABC#show ethernet loopback active
Wed Jan 11 14:29:07.191 IST
Local: TenGigE0/0/0/29, ID 4
=============================================
Direction:                           External
Time out:                              0h5m0s
Time left:                             0h3m49s
Status:                                Active
Filters:
  Dot1Q:                                  Any
  inner-dot1Q:                            Any
  Source MAC Address:                     Any
  Destination MAC Address:    008a.9678.781c
  Ethertype:                              Any
  Class of Service:                       Any


Router:ABC#ethernet loopback start local interface  TenGigE0/0/0/29 external  destination
mac-addRP/0/RSP0/CPU0:PE3-ASR9901#ethernet loopback stop local interface tenGigE 0/0/0/29
id 4
Wed Jan 11 14:29:31.753 IST
LC/0/0/CPU0:Jan 11 14:29:32.022 IST: EDPL-MA[354]: %L2-ETH_LB-6-SESSION_STOPPED : Attempt
to stop session 4 on interface TenGigE0/0/0/29 has completed.
Session with ID 4 on interface TenGigE0/0/0/29 successfully stopped.
```

Ethernet Data Plane Loopback on Satellite nV System

The Ethernet Data Plane Loopback (EDPL) is implemented on the Satellite nV System as shown in this illustration.

Figure 12: EDPL on Satellite nV System



The internal and external EDPL on satellite are realized as follows:

- **Internal Loopback**: The MAC address swap happens on the host and the frame actually gets looped back from the satellite where Layer 1 loopback needs to be turned on at the port. As the entire port is looped back on the satellite, the internal loopback for satellite ports cannot loopback or filter specific sub-interface sessions on the port. You need to enable both EDPL and port L1 internal loopback on the satellite port for this functionality.
- **External Loopback**: The external loopback is currently implemented entirely on the host because of the need to perform MAC address swap.

Limitations of Ethernet Data Plane Loopback on nV Satellite System

Following are the limitations of Ethernet Data Plane Loopback (EDPL) on nV Satellite system:

- LAG bundles that are member of Satellite nV interface over bundle inter-chassis link (also known as LAG over LAG bundles) are not supported.
- If ICL is non-redundant(non-bundle), ethernet loopback internal on satellite access interfaces is not supported.

Configuring EDPL on nV Satellite System

To enable and start Ethernet Data Plane Loopback (EDPL) on an nV satellite system, perform the following steps:

/* Enable ethernet internal loopback on satellite interfaces */

```
RP/0/RSP0/CPU0:router#config
RP/0/RSP0/CPU0:router(config)#interface gi200/0/0/8
RP/0/RSP0/CPU0:router(config-if)#ethernet loopback permit internal
RP/0/RSP0/CPU0:router(config-if)#commit
RP/0/RSP0/CPU0:router(config-if)#end
```

/* Enable ethernet external loopback on satellite interfaces */

```
RP/0/RSP0/CPU0:router#config
RP/0/RSP0/CPU0:router(config)#interface gi200/0/0/10
RP/0/RSP0/CPU0:router(config-if)#ethernet loopback permit external
RP/0/RSP0/CPU0:router(config-if)#commit
RP/0/RSP0/CPU0:router(config-if)#end
```

/* Start an EDPL session */

```
RP/0/RSP0/CPU0:router#ethernet loopback start local interface gigabitEthernet 200/0/0/10
external destination mac-address 70b3.1778.ef41
Session on interface GigabitEthernet200/0/0/10 successfully created with ID 2.
```

Note To stop an EDLP session, use the **ethernet loopback stop local interface** <*name*> **id** <*id*> command.

Running Configuration

The following configuration displays EDPL on an nv satellite, a bundle interface, and on an interface.

```
RP/0/RSP0/CPU0:router#show run nv satellite 200
nv
satellite 200
  type asr9000v2
  ip address 100.100.1.3
  description sat 200
```

```
!
!
RP/0/RSP0/CPU0:router#show run interface bundle-ether 22
interface Bundle-Ether22
ipv4 point-to-point
ipv4 unnumbered Loopback10
nv
  satellite-fabric-link satellite 200
   remote-ports GigabitEthernet 0/0/0-39
  !
!
!
RP/0/RSP0/CPU0:router#show run interface TenGigE0/3/0/2/2
interface TenGigE0/3/0/2/2
bundle id 22 mode on
!
RP/0/RSP0/CPU0:router#show run interface TenGigE0/3/0/5/2
interface TenGigE0/3/0/5/2
bundle id 22 mode on
!
```

Verification

Verify that the internal and external loopback are active.

```
RP/0/RSP0/CPU0:router#show ethernet loopback permitted
Local Loopback
Interface                     Direction
-----------------------------------------------
GigabitEthernet200/0/0/10     External
GigabitEthernet200/0/0/8      Internal

Latching Loopback
Interface                     Direction
-----------------------------------------------

Loopback Controller
Interface
-----------------------------------------------

RP/0/RSP0/CPU0:router#show ethernet loopback active

Local: GigabitEthernet200/0/0/10, ID 2
=======================================
Direction:                          External
Time out:                             0h5m0s
Time left:                           0h4m53s
Status:                               Active
Filters:
  Dot1Q:                                 Any
  inner-dot1Q:                           Any
  Source MAC Address:                    Any
  Destination MAC Address:    70b3.1778.ef41
  Ethertype:                             Any
  Class of Service:                      Any
```

Verify that the satellite is ready.

```
RP/0/RSP0/CPU0:router#show nv satellite status satellite 200
Satellite 200
-------------
  Status: Connected (Stable)
  Type: asr9000v2
```

```
Description: sat 200
Displayed device name: Sat200
MAC address: 70b3.1778.ef38
IPv4 address: 100.100.1.3 (VRF: default)
Serial Number: CAT2243U002
Remote version: Compatible (latest version)
  ROMMON: 128.1 (Latest)
  FPGA: 1.13 (Latest)
  IOS: 781.1 (Latest)
Received candidate fabric ports:
  nVFabric-GigE0/0/42-43 (permanent)
  nVFabric-TenGigE0/0/44-47 (permanent)
Configured satellite fabric links:
  Bundle-Ether22
  --------------
    Status: Satellite Ready
    Remote ports: GigabitEthernet0/0/0-39
    Discovered satellite fabric links:
      TenGigE0/3/0/2/2: Satellite Ready; No conflict
      TenGigE0/3/0/5/2: Satellite Ready; No conflict
```

How to Configure Ethernet OAM

This section provides these configuration procedures:

Configuring Ethernet Link OAM

Custom EOAM settings can be configured and shared on multiple interfaces by creating an EOAM profile in Ethernet configuration mode and then attaching the profile to individual interfaces. The profile configuration does not take effect until the profile is attached to an interface. After an EOAM profile is attached to an interface, individual EOAM features can be configured separately on the interface to override the profile settings when desired.

This section describes how to configure an EOAM profile and attach it to an interface in these procedures:

Configuring an Ethernet OAM Profile

Perform these steps to configure an Ethernet OAM profile.

SUMMARY STEPS

1. **configure**
2. **ethernet oam profile** *profile-name*
3. **link-monitor**
4. **symbol-period window** *window*
5. **symbol-period threshold low** *threshold* **high** *threshold*
6. **frame window** *window*
7. **frame threshold low** *threshold* **high** *threshold*
8. **frame-period window** *window*
9. **frame-period threshold low***threshold* **high** *threshold*
10. **frame-seconds window** *window*
11. **frame-seconds threshold low** *threshold* **high** *threshold*

12. **exit**
13. **mib-retrieval**
14. **connection timeout** <*timeout*>
15. **hello-interval** {**100ms**|**1s**}
16. **mode** {**active**|**passive**}
17. **require-remote mode** {**active**|**passive**}
18. **require-remote mib-retrieval**
19. **action capabilities-conflict** {**disable | efd | error-disable-interface**}
20. **action critical-event** {**disable** | **error-disable-interface**}
21. **action discovery-timeout** {**disable** | **efd** | **error-disable-interface**}
22. **action dying-gasp** {**disable** | **error-disable-interface**}
23. **action high-threshold** {**error-disable-interface** | **log**}
24. **action session-down** {**disable** | **efd** | **error-disable-interface**}
25. **action session-up disable**
26. **action uni-directional link-fault** {**disable** | **efd** | **error-disable-interface**}
27. **action wiring-conflict** {**disable | efd | log**}
28. **uni-directional link-fault detection**
29. **commit**
30. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure terminal`	Enters global configuration mode.
Step 2	**ethernet oam profile** *profile-name* **Example:** `RP/0/RSP0/CPU0:router(config)# ethernet oam profile Profile_1`	Creates a new Ethernet Operations, Administration and Maintenance (OAM) profile and enters Ethernet OAM configuration mode.
Step 3	**link-monitor** **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# link-monitor`	Enters the Ethernet OAM link monitor configuration mode.
Step 4	**symbol-period window** *window* **Example:** `RP/0/RSP0/CPU0:router(config-eoam-lm)# symbol-period window 60000`	(Optional) Configures the window size (in milliseconds) for an Ethernet OAM symbol-period error event. The IEEE 802.3 standard defines the window size as a number of symbols rather than a time duration. These two formats can be converted either way by using a knowledge of the interface speed and encoding. The range is 1000 to 60000.

	Command or Action	Purpose
		The default value is 1000.
Step 5	**symbol-period threshold low** *threshold* **high** *threshold* **Example:** `RP/0/RSP0/CPU0:router(config-eoam-lm)# symbol-period threshold ppm low 1 high 1000000`	(Optional) Configures the thresholds (in symbols) that trigger an Ethernet OAM symbol-period error event. The high threshold is optional and is configurable only in conjunction with the low threshold. The range is 0 to 60000000. The default low threshold is 1.
Step 6	**frame window** *window* **Example:** `RP/0/RSP0/CPU0:router(config-eoam-lm)# frame window 6000`	(Optional) Configures the frame window size (in milliseconds) of an OAM frame error event. The range is from 1000 to 60000. The default value is 1000.
Step 7	**frame threshold low** *threshold* **high** *threshold* **Example:** `RP/0/RSP0/CPU0:router(config-eoam-lm)# frame threshold low 10000000 high 60000000`	(Optional) Configures the thresholds (in symbols) that triggers an Ethernet OAM frame error event. The high threshold is optional and is configurable only in conjunction with the low threshold. The range is from 0 to 60000000. The default low threshold is 1.

Step 8	**frame-period window** *window*
	Example:
	`RP/0/RSP0/CPU0:router(config-eoam-lm)# frame-period window 60000`
	`RP/0/RSP0/CPU0:router(config-eoam-lm)# frame-period window milliseconds 60000`
		(Optional) Configures the window size (in milliseconds) for an Ethernet OAM frame-period error event. The IEEE 802.3 standard defines the window size as number of frames rather than a time duration. These two formats can be converted either way by using a knowledge of the interface speed. Note that the conversion assumes that all frames are of the minimum size.
		The range is from 1000 to 60000.
		The default value is 1000.
		Note The only accepted values are multiples of the line cardinterface module-specific polling interval, that is, 1000 milliseconds for most line cardsinterface modules.

Step 9	**frame-period threshold low***threshold* **high** *threshold* **Example:** `RP/0/RSP0/CPU0:router(config-eoam-lm)# frame-period threshold ppm low 100 high 1000000`	(Optional) Configures the thresholds (in errors per million frames) that trigger an Ethernet OAM frame-period error event. The frame period window is defined in the IEEE specification as a number of received frames, in our implementation it is x milliseconds. The high threshold is optional and is configurable only in conjunction with the low threshold. The range is from 1 to 1000000. The default low threshold is 1.

	Command or Action	Purpose
		To obtain the number of frames, the configured time interval is converted to a window size in frames using the interface speed. For example, for a 1Gbps interface, the IEEE defines minimum frame size as 512 bits. So, we get a maximum of approximately 1.5 million frames per second. If the window size is configured to be 8 seconds (8000ms) then this would give us a Window of 12 million frames in the specification's definition of Errored Frame Window. The thresholds for frame-period are measured in errors per million frames. Hence, if you configure a window of 8000ms (that is a window of 12 million frames) and a high threshold of 100, then the threshold would be crossed if there are 1200 errored frames in that period (that is, 100 per million for 12 million).
Step 10	**frame-seconds window** *window* **Example:** `RP/0/RSP0/CPU0:router(config-eoam-lm)# frame-seconds window 900000`	(Optional) Configures the window size (in milliseconds) for the OAM frame-seconds error event. The range is 10000 to 900000. The default value is 60000. **Note** The only accepted values are multiples of the line cardinterface module-specific polling interval, that is, 1000 milliseconds for most line cardsinterface modules.
Step 11	**frame-seconds threshold low** *threshold* **high** *threshold* **Example:** `RP/0/RSP0/CPU0:router(config-eoam-lm)# frame-seconds threshold low 3 high 900`	(Optional) Configures the thresholds (in seconds) that trigger a frame-seconds error event. The high threshold value can be configured only in conjunction with the low threshold value. The range is 1 to 900 The default value is 1.
Step 12	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-eoam-lm)# exit`	Exits back to Ethernet OAM mode.
Step 13	**mib-retrieval** **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# mib-retrieval`	Enables MIB retrieval in an Ethernet OAM profile or on an Ethernet OAM interface.
Step 14	**connection timeout** <*timeout*> **Example:**	Configures the connection timeout period for an Ethernet OAM session. as a multiple of the hello interval. The range is 2 to 30.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-eoam)# connection timeout 30`	The default value is 5.
Step 15	**hello-interval** {**100ms**|**1s**} **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# hello-interval 100ms`	Configures the time interval between hello packets for an Ethernet OAM session. The default is 1 second (**1s**).
Step 16	**mode** {**active**|**passive**} **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# mode passive`	Configures the Ethernet OAM mode. The default is active.
Step 17	**require-remote mode** {**active**|**passive**} **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# require-remote mode active`	Requires that active mode or passive mode is configured on the remote end before the OAM session becomes active.
Step 18	**require-remote mib-retrieval** **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# require-remote mib-retrieval`	Requires that MIB-retrieval is configured on the remote end before the OAM session becomes active.
Step 19	**action capabilities-conflict** {**disable | efd | error-disable-interface**} **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# action capabilities-conflict efd`	Specifies the action that is taken on an interface when a capabilities-conflict event occurs. The default action is to create a syslog entry. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 20	**action critical-event** {**disable** | **error-disable-interface**} **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# action critical-event error-disable-interface`	Specifies the action that is taken on an interface when a critical-event notification is received from the remote Ethernet OAM peer. The default action is to create a syslog entry. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.

	Command or Action	Purpose
Step 21	**action discovery-timeout** {**disable** | **efd** | **error-disable-interface**} **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# action discovery-timeout efd`	Specifies the action that is taken on an interface when a connection timeout occurs. The default action is to create a syslog entry. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 22	**action dying-gasp** {**disable** | **error-disable-interface**} **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# action dying-gasp error-disable-interface`	Specifies the action that is taken on an interface when a dying-gasp notification is received from the remote Ethernet OAM peer. The default action is to create a syslog entry. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 23	**action high-threshold** {**error-disable-interface** | **log**} **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# action high-threshold error-disable-interface`	Specifies the action that is taken on an interface when a high threshold is exceeded. The default is to take no action when a high threshold is exceeded. **Note** • If you change the default, the **disable** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and take no action at the interface when the event occurs.
Step 24	**action session-down** {**disable** | **efd** | **error-disable-interface**} **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# action session-down efd`	Specifies the action that is taken on an interface when an Ethernet OAM session goes down. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 25	**action session-up disable** **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# action session-up disable`	Specifies that no action is taken on an interface when an Ethernet OAM session is established. The default action is to create a syslog entry.

	Command or Action	Purpose
		Note • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 26	**action uni-directional link-fault** {**disable** | **efd** | **error-disable-interface**}	Specifies the action that is taken on an interface when a link-fault notification is received from the remote Ethernet OAM peer. The default action is to create a syslog entry. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 27	**action wiring-conflict** {**disable | efd | log**} **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# action session-down efd`	Specifies the action that is taken on an interface when a wiring-conflict event occurs. The default is to put the interface into error-disable state. **Note** • If you change the default, the **error-disable-interface** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and put the interface into error-disable state when the event occurs.
Step 28	**uni-directional link-fault detection** **Example:** `RP/0/RSP0/CPU0:router(config-eoam)# uni-directional link-fault detection`	Enables detection of a local, unidirectional link fault and sends notification of that fault to an Ethernet OAM peer.
Step 29	**commit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.
Step 30	**end** **Example:** `RP/0/RSP0/CPU0:router(config-if)# end`	Ends the configuration session and exits to the EXEC mode.

Attaching an Ethernet OAM Profile to an Interface

Perform these steps to attach an Ethernet OAM profile to an interface:

SUMMARY STEPS

1. **configure**
2. **interface** [**FastEthernet** | **HundredGigE**| **TenGigE**] *interface-path-id*
3. **ethernet oam**
4. **profile** *profile-name*
5. **commit**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure terminal`	Enters global configuration mode.
Step 2	**interface** [**FastEthernet**	**HundredGigE**| **TenGigE**] *interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface TenGigE 0/1/0/0`	Enters interface configuration mode and specifies the Ethernet interface name and notation *rack/slot/module/port*. **Note** • The example indicates an 8-port 10-Gigabit Ethernet interface in modular services card slot 1.
Step 3	**ethernet oam** **Example:** `RP/0/RSP0/CPU0:router(config-if)# ethernet oam`	Enables Ethernet OAM and enters interface Ethernet OAM configuration mode.
Step 4	**profile** *profile-name* **Example:** `RP/0/RSP0/CPU0:router(config-if-eoam)# profile Profile_1`	Attaches the specified Ethernet OAM profile (*profile-name*), and all of its configuration, to the interface.
Step 5	**commit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.
Step 6	**end** **Example:** `RP/0/RSP0/CPU0:router(config-if)# end`	Ends the configuration session and exits to the EXEC mode.

Configuring Ethernet OAM at an Interface and Overriding the Profile Configuration

Using an EOAM profile is an efficient way of configuring multiple interfaces with a common EOAM configuration. However, if you want to use a profile but also change the behavior of certain functions for a

particular interface, then you can override the profile configuration. To override certain profile settings that are applied to an interface, you can configure that command in interface Ethernet OAM configuration mode to change the behavior for that interface.

In some cases, only certain keyword options are available in interface Ethernet OAM configuration due to the default settings for the command. For example, without any configuration of the **action** commands, several forms of the command have a default behavior of creating a syslog entry when a profile is created and applied to an interface. Therefore, the **log** keyword is not available in Ethernet OAM configuration for these commands in the profile because it is the default behavior. However, the **log** keyword is available in Interface Ethernet OAM configuration if the default is changed in the profile configuration so you can retain the action of creating a syslog entry for a particular interface.

To see all of the default Ethernet OAM configuration settings, see the *Verifying the Ethernet OAM Configuration* section.

To configure Ethernet OAM settings at an interface and override the profile configuration, perform these steps:

SUMMARY STEPS

1. **configure**
2. **interface** [GigabitEthernet | TenGigE] *interface-path-id*
3. **ethernet oam**
4. *interface-Ethernet-OAM-command* RP/0/RSP0/CPU0:router(config-if-eoam)# action capabilities-conflict error-disable-interface
5. **commit**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure terminal`	Enters global configuration mode.
Step 2	**interface** [GigabitEthernet | TenGigE] *interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface TenGigE 0/1/0/0`	Enters interface configuration mode and specifies the Ethernet interface name and notation *rack/slot/module/port*. **Note** • The example indicates an 8-port 10-Gigabit Ethernet interface in modular services card slot 1.
Step 3	**ethernet oam** **Example:** `RP/0/RSP0/CPU0:router(config-if)# ethernet oam`	Enables Ethernet OAM and enters interface Ethernet OAM configuration mode.
Step 4	*interface-Ethernet-OAM-command* RP/0/RSP0/CPU0:router(config-if-eoam)# action capabilities-conflict error-disable-interface	Configures a setting for an Ethernet OAM configuration command and overrides the setting for the profile configuration, where *interface-Ethernet-OAM-command* is

	Command or Action	Purpose
		one of the supported commands on the platform in interface Ethernet OAM configuration mode.
Step 5	**commit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.
Step 6	**end** **Example:** `RP/0/RSP0/CPU0:router(config-if)# end`	Ends the configuration session and exits to the EXEC mode.

Verifying the Ethernet OAM Configuration

Use the **show ethernet oam configuration** command to display the values for the Ethernet OAM configuration for a particular interface, or for all interfaces. The following example shows the default values for Ethernet OAM settings:

```
RP/0/RSP0/CPU0:router# show ethernet oam configuration
Thu Aug  5 22:07:06.870 DST
GigabitEthernet0/4/0/0:
  Hello interval:                                        1s
  Link monitoring enabled:                                Y
  Remote loopback enabled:                                N
  Mib retrieval enabled:                                  N
  Uni-directional link-fault detection enabled:           N
  Configured mode:                                   Active
  Connection timeout:                                     5
  Symbol period window:                                   0
  Symbol period low threshold:                            1
  Symbol period high threshold:                        None
  Frame window:                                        1000
  Frame low threshold:                                    1
  Frame high threshold:                                None
  Frame period window:                                 1000
  Frame period low threshold:                             1
  Frame period high threshold:                         None
  Frame seconds window:                               60000
  Frame seconds low threshold:                            1
  Frame seconds high threshold:                        None
  High threshold action:                               None
  Link fault action:                                    Log
  Dying gasp action:                                    Log
  Critical event action:                                Log
  Discovery timeout action:                             Log
  Capabilities conflict action:                         Log
  Wiring conflict action:                     Error-Disable
  Session up action:                                    Log
  Session down action:                                  Log
  Remote loopback action:                               Log
  Require remote mode:                               Ignore
  Require remote MIB retrieval:                           N
  Require remote loopback support:                        N
  Require remote link monitoring:                         N
```

Configuring Ethernet CFM

To configure Ethernet CFM, perform the following tasks:

Configuring a CFM Maintenance Domain

To configure a CFM maintenance domain, perform the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
4. **traceroute cache hold-time** *minutes* **size** *entries*
5. **end** or **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RSP0/CPU0:router(config)# ethernet cfm`	Enters Ethernet Connectivity Fault Management (CFM) configuration mode.
Step 3	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RSP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations and enters CFM domain configuration mode. The level must be specified. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 4	**traceroute cache hold-time** *minutes* **size** *entries* **Example:** `RP/0/RSP0/CPU0:router(config-cfm)# traceroute cache hold-time 1 size 3000`	(Optional) Sets the maximum limit of traceroute cache entries or the maximum time limit to hold the traceroute cache entries. The default is 100 minutes and 100 entries.
Step 5	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before`

	Command or Action	Purpose
		exiting(yes/no/cancel)? [cancel]: • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Services for a CFM Maintenance Domain

You can configure up to 32000 CFM services for a maintenance domain.

Before you begin

To configure services for a CFM maintenance domain, perform the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
4. **service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]]
5. **end** or **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RSP0/CPU0:router(config)# ethernet cfm`	Enters Ethernet CFM configuration mode.

	Command or Action	Purpose
Step 3	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RSP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations at a specified maintenance level, and enters CFM domain configuration mode. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 4	**service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]] **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn)# service Bridge_Service bridge group BD1 bridge-domain B1`	Configures and associates a service with the domain and enters CFM domain service configuration mode. You can specify that the service is used only for down MEPs, or associate the service with a bridge domain or xconnect where MIPs and up MEPs will be created. The **id** sets the short MA name.
Step 5	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Enabling and Configuring Continuity Check for a CFM Service

The Cisco ASR 9000 Series Router supports Continuity Check as defined in the IEEE 802.1ag specification, and supports CCMs intervals of 100 ms and longer. The overall packet rates for CCM messages are up to 16000 CCMs-per-second sent, and up to 16000 CCMs-per-second received, per card.

Note If Ethernet SLA is configured, the overall combined packet rate for CCMs and SLA frames is 16000 frames-per-second in each direction, per card.

To configure Continuity Check for a CFM service, complete the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
4. **service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]]
5. **continuity-check interval** *time* [**loss-threshold** *threshold*]
6. **continuity-check archive hold-time** *minutes*
7. **continuity-check loss auto-traceroute**
8. **end** or **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RSP0/CPU0:router(config)# ethernet cfm`	Enters Ethernet Connectivity Fault Management (CFM) configuration mode.
Step 3	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RSP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations and enters the CFM domain configuration mode. The level must be specified. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 4	**service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name*	**down-meps	xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*]	[**string** *text*]	[**number** *number*]	[**vlan-id** *id-number*]	[**vpn-id** *oui-vpnid*]] **Example:**	Configures and associates a service with the domain and enters CFM domain service configuration mode. You can specify that the service is used only for down MEPs, or associate the service with a bridge domain or xconnect where MIPs and up MEPs will be created. The **id** sets the short MA name.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-cfm-dmn)# service Bridge_Service bridge group BD1 bridge-domain B1`	
Step 5	**continuity-check interval** *time* [**loss-threshold** *threshold*] **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# continuity-check interval 100m loss-threshold 10`	(Optional) Enables Continuity Check and specifies the time interval at which CCMs are transmitted or to set the threshold limit for when a MEP is declared down.
Step 6	**continuity-check archive hold-time** *minutes* **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# continuity-check archive hold-time 100`	(Optional) Configures how long information about peer MEPs is stored after they have timed out.
Step 7	**continuity-check loss auto-traceroute** **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# continuity-check loss auto-traceroute`	(Optional) Configures automatic triggering of a traceroute when a MEP is declared down.
Step 8	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Automatic MIP Creation for a CFM Service

For more information about the algorithm for creating MIPs, see the MIP Creation.

To configure automatic MIP creation for a CFM service, complete the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
4. **service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]]
5. **mip auto-create** {**all** | **lower-mep-only**} {**ccm-learning**}
6. **end** or **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RSP0/CPU0:router# ethernet cfm`	Enters the Ethernet Connectivity Fault Management (CFM) configuration mode.
Step 3	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RSP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations and enters the CFM domain configuration mode. The level must be specified. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 4	**service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name*	**down-meps	xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*]	[**string** *text*]	[**number** *number*]	[**vlan-id** *id-number*]	[**vpn-id** *oui-vpnid*]] **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn)# service Bridge_Service bridge group BD1 bridge-domain B1`	Configures and associates a service with the domain and enters CFM domain service configuration mode. You can specify that the service is used only for down MEPs, or associate the service with a bridge domain or xconnect where MIPs and up MEPs will be created. The **id** sets the short MA name.
Step 5	**mip auto-create** {**all**	**lower-mep-only**} {**ccm-learning**} **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# mip auto-create all ccm-learning`	(Optional) Enables the automatic creation of MIPs in a bridge domain or xconnect. **ccm-learning** option enables CCM learning for MIPs created in this service. This must be used only in services with a relatively long CCM interval of at least 100 ms. CCM learning at MIPs is disabled by default.

	Command or Action	Purpose
Step 6	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Cross-Check on a MEP for a CFM Service

To configure cross-check on a MEP for a CFM service and specify the expected set of MEPs, complete the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
4. **service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]]
5. **mep crosscheck**
6. **mep-id** *mep-id-number* [**mac-address** *mac-address*]
7. **end** or **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**ethernet cfm** **Example:** `RP/0/RSP0/CPU0:router# ethernet cfm`	Enters the Ethernet Connectivity Fault Management (CFM) configuration mode.
Step 3	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RSP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations and enters the CFM domain configuration mode. The level must be specified. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 4	**service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]] **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn)# service Bridge_Service bridge group BD1 bridge-domain B1`	Configures and associates a service with the domain and enters CFM domain service configuration mode. You can specify that the service is used only for down MEPs, or associate the service with a bridge domain or xconnect where MIPs and up MEPs will be created. The **id** sets the short MA name.
Step 5	**mep crosscheck** **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# mep crosscheck mep-id 10`	Enters CFM MEP crosscheck configuration mode.
Step 6	**mep-id** *mep-id-number* [**mac-address** *mac-address*] **Example:** `RP/0/RSP0/CPU0:router(config-cfm-xcheck)# mep-id 10`	Enables cross-check on a MEP. **Note** • Repeat this command for every MEP that you want included in the expected set of MEPs for cross-check.
Step 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-cfm-xcheck)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.

	Command or Action	Purpose
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Other Options for a CFM Service

To configure other options for a CFM service, complete the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
4. **service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps** | **xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]]
5. **maximum-meps** *number*
6. **log** {**ais**|**continuity-check errors**|**continuity-check mep changes**|**crosscheck errors**|**efd**}
7. **end** or **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RSP0/CPU0:router# ethernet cfm`	Enters the Ethernet Connectivity Fault Management (CFM) configuration mode.
Step 3	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RSP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations and enters the CFM domain configuration mode. The level must be specified. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association

	Command or Action	Purpose
		identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 4	**service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps** | **xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]] **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn)# service Bridge_Service bridge group BD1 bridge-domain B1`	Configures and associates a service with the domain and enters CFM domain service configuration mode. You can specify that the service is used only for down MEPs, or associate the service with a bridge domain or xconnect where MIPs and up MEPs will be created. The **id** sets the short MA name.
Step 5	**maximum-meps** *number* **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# maximum-meps 1000`	(Optional) Configures the maximum number (2 to 8190) of MEPs across the network, which limits the number of peer MEPs recorded in the database.
Step 6	**log** {**ais**|**continuity-check errors**|**continuity-check mep changes**|**crosscheck errors**|**efd**} **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# log continuity-check errors`	(Optional) Enables logging of certain types of events.
Step 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring CFM MEPs

When you configure CFM MEPs, consider these guidelines:

- Up to 32000 local MEPs are supported per card.
- CFM maintenance points can be created on these interface types:
  - All physical Ethernet interfaces (except for the RSP Management interfaces).
  - Ethernet bundle interfaces.
  - All physical and bundle Ethernet sub-interfaces, providing the encapsulation is configured according to the following guidelines:

    Frames are only matched based on VLAN IDs and CoS bits.

    Frames are not matched using VLAN "any."

    If frames are untagged, then the interface configuration on the Cisco ASR 9000 Series Router is such that there is no ambiguity on the sub-interface to which the untagged frame must be classified.
  - Ethernet bundle member interfaces—Only down MEPs at level 0 can be created.
- CFM maintenance points can be created on both Layer 2 and Layer 3 interfaces. On L3 interfaces, only down MEPs can be created.
- A new configuration under the MEP submode called loss-measurement counters is used to allocate the packet counters used for LMM.

Restrictions

When you configure MEPs, consider these restrictions:

- Maintenance points at level 0 are not supported on bundle interfaces.
- CFM on Cisco IOS XR Software does not support a tag stack of more than two tags.
- If a subinterface is configured that matches untagged Ethernet frames (for example, by configuring the **encapsulation default** command), then you can not create a down MEP on the underlying physical or bundle interface.
- Up MEPs are not supported on Layer 3 interfaces.
- CCM packet must not go through L3VPN cloud.
- LBM/LBR packet must not go through L3VPN cloud.
- LTM/LTR packet must not go through L3VPN cloud.
- DMM/DMR packet must not go through L3VPN cloud.
- SLM/SLR packet must not go through L3VPN cloud.
- LMM/LMR packet must not go through L3VPN cloud.

SUMMARY STEPS

1. **configure**
2. **interface** {**GigabitEthernet | TenGigE**} *interface-path-id*

3. **interface** {**GigabitEthernet | TenGigE | Bundle-Ether**} *interface-path-id.subinterface*
4. **vrf vrf-name**
5. **interface** {**FastEthernet | GigabitEthernet | TenGigE**} *interface-path-id*
6. **ethernet cfm**
7. **mep domain** *domain-name* **service** *service-name* **mep-id** *id-number*
8. **cos** *cos*
9. **end** or **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface** {**GigabitEthernet	TenGigE**} *interface-path-id* **Example:** `RP/0//CPU0:router(config)# interface gigabitethernet 0/1/0/1`	Type of Ethernet interface on which you want to create a MEP. Enter **GigabitEthernet** or **TenGigE** and the physical interface or virtual interface. **Note** • Use the **show interfaces** command to see a list of all interfaces currently configured on the router. For more information about the syntax for the router, use the question mark (**?**) online help function.
Step 3	**interface** {**GigabitEthernet	TenGigE	Bundle-Ether**} *interface-path-id.subinterface* **Example:** `RP/0/RSP0/CPU0:router(config)# interface gigabitethernet 0/1/0/1`	Type of Ethernet interface on which you want to create a MEP. Enter **GigabitEthernet, TenGigE,** or **Bundle-Ether** and the physical interface or virtual interface followed by the subinterface path ID. Naming notation is *interface-path-id.subinterface*. The period in front of the subinterface value is required as part of the notation. For more information about the syntax for the router, use the question mark (**?**) online help function.
Step 4	**vrf vrf-name** **Example:** `RP/0/RSP0/CPU0:router(config-if)# vrf vrf_A`	Configures a VRF instance and enters VRF configuration mode. For more information on configuring VRF interfaces, refer the *Connecting MPLS VPN Customers* section in the *Cisco ASR 9000 Series MPLS Layer 3 VPN Configuration Guide*.
Step 5	**interface** {**FastEthernet	GigabitEthernet	TenGigE**} *interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface gigabitethernet 0/1/0/1`	Type of Ethernet interface on which you want to create a MEP. Enter **FastEthernet, GigabitEthernet** or **TenGigE** and the physical interface or virtual interface. **Note** • Use the **show interfaces** command to see a list of all interfaces currently configured on the router.

	Command or Action	Purpose
		For more information about the syntax for the router, use the question mark (**?**) online help function.
Step 6	**ethernet cfm** **Example:** `RP/0/RSP0/CPU0:router(config-if)# ethernet cfm`	Enters interface Ethernet CFM configuration mode.
Step 7	**mep domain** *domain-name* **service** *service-name* **mep-id** *id-number* **Example:** `RP/0/RSP0/CPU0:router(config-if-cfm)# mep domain Dm1 service Sv1 mep-id 1`	Creates a maintenance end point (MEP) on an interface and enters interface CFM MEP configuration mode.
Step 8	**cos** *cos* **Example:** `RP/0/RSP0/CPU0:router(config-if-cfm-mep)# cos 7`	(Optional) Configures the class of service (CoS) (from 0 to 7) for all CFM packets generated by the MEP on an interface. If not configured, the CoS is inherited from the Ethernet interface. **Note** For Ethernet interfaces, the CoS is carried as a field in the VLAN tag. Therefore, CoS only applies to interfaces where packets are sent with VLAN tags. If the **cos (CFM)** command is executed for a MEP on an interface that does not have a VLAN encapsulation configured, it will be ignored.
Step 9	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-if-cfm-mep)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Y.1731 AIS

This section has the following step procedures:

Configuring AIS in a CFM Domain Service

Use the following procedure to configure Alarm Indication Signal (AIS) transmission for a CFM domain service and configure AIS logging.

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *name* **level** *level*
4. **service** *name* **bridge group** *name* **bridge-domain** *name*
5. **service** *name* **xconnect group** *xconnect-group-name* **p2p** *xconnect-name*
6. **ais transmission** [**interval** {**1s**|**1m**}][**cos** *cos*]
7. **log ais**
8. **end** or **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0//CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0//CPU0:router(config)# ethernet cfm`	Enters Ethernet CFM global configuration mode.
Step 3	**domain** *name* **level** *level* **Example:** `RP/0//CPU0:router(config-cfm)# domain D1 level 1`	Specifies the domain and domain level.
Step 4	**service** *name* **bridge group** *name* **bridge-domain** *name* **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn)# service S1 bridge group BG1 bridge-domain BD2`	Specifies the service, bridge group, and bridge domain.
Step 5	**service** *name* **xconnect group** *xconnect-group-name* **p2p** *xconnect-name* **Example:**	Specifies the service and cross-connect group and name.

	Command or Action	Purpose
	`RP/0//CPU0:router(config-cfm-dmn)# service S1 bridge group BG1 bridge-domain BD2`	
Step 6	**ais transmission** [**interval** {**1s**|**1m**}][**cos** *cos*] **Example:** `RP/0//CPU0:router(config-cfm-dmn-svc)# ais transmission interval 1m cos 7`	Configures Alarm Indication Signal (AIS) transmission for a Connectivity Fault Management (CFM) domain service.
Step 7	**log ais** **Example:** `RP/0//CPU0:router(config-cfm-dmn-svc)# log ais`	Configures AIS logging for a Connectivity Fault Management (CFM) domain service to indicate when AIS or LCK packets are received.
Step 8	**end** or **commit** **Example:** `RP/0//CPU0:router(config-sla-prof-stat-cfg)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring AIS on a CFM Interface

To configure AIS on a CFM interface, perform the following steps:

SUMMARY STEPS

1. **configure**
2. **interface gigabitethernet** *interface-path-id*
3. **ethernet cfm**
4. **ais transmission up interval 1m cos** *cos*
5. **end** or **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0//CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface gigabitethernet** *interface-path-id* **Example:** `RP/0//CPU0:router# interface gigabitethernet 0/1/0/2`	Enters interface configuration mode.
Step 3	**ethernet cfm** **Example:** `RP/0//CPU0:router(config)# ethernet cfm`	Enters Ethernet CFM interface configuration mode.
Step 4	**ais transmission up interval 1m cos** *cos* **Example:** `RP/0//CPU0:router(config-if-cfm)# ais transmission up interval 1m cos 7`	Configures Alarm Indication Signal (AIS) transmission on a Connectivity Fault Management (CFM) interface.
Step 5	**end** or **commit** **Example:** `RP/0//CPU0:router(config-sla-prof-stat-cfg)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring EFD for a CFM Service

To configure EFD for a CFM service, complete the following steps.

Restrictions

EFD is not supported on up MEPs. It can only be configured on down MEPs, within a particular service.

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *domain-name* **level** *level-value*
4. **service** *service-name* **down-meps**
5. **efd**
6. **log efd**
7. **end** or **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0//CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0//CPU0:router(config)# ethernet cfm`	Enters CFM configuration mode.
Step 3	**domain** *domain-name* **level** *level-value* **Example:** `RP/0//CPU0:router(config-cfm-dmn)# domain D1 level 1`	Specifies or creates the CFM domain and enters CFM domain configuration mode.
Step 4	**service** *service-name* **down-meps** **Example:** `RP/0//CPU0:router(config-cfm-dmn)# service S1 down-meps`	Specifies or creates the CFM service for down MEPS and enters CFM domain service configuration mode.
Step 5	**efd** **Example:** `RP/0//CPU0:router(config-cfm-dmn-svc)# efd`	Enables EFD on all down MEPs in the down MEPS service.
Step 6	**log efd** **Example:**	(Optional) Enables logging of EFD state changes on an interface.

	Command or Action	Purpose
	`RP/0//CPU0:router(config-cfm-dmn-svc)# log efd`	
Step 7	**end** or **commit** **Example:** `RP/0//CPU0:router(config-cfm-dmn-svc)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Verifying the EFD Configuration

This example shows how to display all interfaces that are shut down because of Ethernet Fault Detection (EFD):

```
RP/0/RSP0/CPU0:router# show efd interfaces

Server VLAN MA
==============
Interface         Clients
------------------------
GigE0/0/0/0.0     CFM
```

Configuring Flexible VLAN Tagging for CFM

Use this procedure to set the number of tags in CFM packets from up MEPs to 1, in a CFM domain service.

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *name* **level** *level*
4. **service** *name* **bridge group** *name* **bridge-domain** *name*
5. **tags** *number*

6. **end** or **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RSP0/CPU0:router(config)# ethernet cfm`	Enters Ethernet CFM global configuration mode.
Step 3	**domain** *name* **level** *level* **Example:** `RP/0/RSP0/CPU0:router(config-cfm)# domain D1 level 1`	Specifies the domain and domain level.
Step 4	**service** *name* **bridge group** *name* **bridge-domain** *name* **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn)# service S2 bridge group BG1 bridge-domain BD2`	Specifies the service, bridge group, and bridge domain.
Step 5	**tags** *number* **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# tags 1`	Specifies the number of tags in CFM packets from up MEPs. Currently, the only valid value is 1.
Step 6	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.

	Command or Action	Purpose
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Verifying the CFM Configuration

To verify the CFM configuration, use one or more of the following commands:

show ethernet cfm configuration-errors [**domain** *domain-name*] [**interface** *interface-path-id*]	Displays information about errors that are preventing configured CFM operations from becoming active, as well as any warnings that have occurred.
show ethernet cfm local maintenance-points domain *name* [**service** *name]* | **interface** *type interface-path-id*] [**mep** | **mip**]	Displays a list of local maintenance points.

Troubleshooting Tips

To troubleshoot problems within the CFM network, perform the following steps:

SUMMARY STEPS

1. To verify connectivity to a problematic MEP, use the **ping ethernet cfm** command as shown in the following example:
2. If the results of the **ping ethernet cfm** command show a problem with connectivity to the peer MEP, use the **traceroute ethernet cfm** command to help further isolate the location of the problem as shown in the following example:

DETAILED STEPS

Step 1 To verify connectivity to a problematic MEP, use the **ping ethernet cfm** command as shown in the following example:

```
RP/0/RSP0/CPU0:router# ping ethernet cfm domain D1 service S1 mep-id 16 source
interface GigabitEthernet 0/0/0/0

Type escape sequence to abort.
Sending 5 CFM Loopbacks, timeout is 2 seconds -
Domain foo (level 2), Service foo
Source: MEP ID 1, interface GigabitEthernet0/0/0/0
Target: 0001.0002.0003 (MEP ID 16):
  Running (5s) ...
Success rate is 60.0 percent (3/5), round-trip min/avg/max = 1251/1349/1402 ms
Out-of-sequence: 0.0 percent (0/3)
Bad data: 0.0 percent (0/3)
Received packet rate: 1.4 pps
```

Step 2 If the results of the **ping ethernet cfm** command show a problem with connectivity to the peer MEP, use the **traceroute ethernet cfm** command to help further isolate the location of the problem as shown in the following example:

```
RP/0/RSP0/CPU0:router# traceroute ethernet cfm domain D1 service S1 mep-id 16 source
 interface gigabitethernet 0/0/0/0

Traceroutes in domain D1 (level 4), service S1
Source: MEP-ID 1, interface GigabitEthernet0/0/0/0
================================================================================
Traceroute at 2009-05-18 12:09:10 to 0001.0203.0402,
TTL 64, Trans ID 2:

Hop Hostname/Last            Ingress MAC/name       Egress MAC/Name        Relay
--- ------------------------ ---------------------- ---------------------- -----
  1 ios                      0001.0203.0400 [Down]                         FDB
     0000-0001.0203.0400     Gi0/0/0/0
  2 abc                                             0001.0203.0401 [Ok]    FDB
     ios                                            Not present
  3 bcd                      0001.0203.0402 [Ok]                           Hit
     abc                     GigE0/0
Replies dropped: 0
```

If the target was a MEP, verify that the last hop shows “Hit” in the Relay field to confirm connectivity to the peer MEP.

If the Relay field contains “MPDB” for any of the hops, then the target MAC address was not found in the bridge MAC learning table at that hop, and the result is relying on CCM learning. This result can occur under normal conditions, but it can also indicate a problem. If you used the **ping ethernet cfm** command before using the **traceroute ethernet cfm** command, then the MAC address should have been learned. If “MPDB” is appearing in that case, then this indicates a problem at that point in the network.

Configuring Ethernet SLA

This section describes how to configure Ethernet SLA.

Ethernet SLA Configuration Guidelines

Caution Certain SLA configurations can use a large amount of memory which can affect the performance of other features on the router.

Before you configure Ethernet SLA, consider the following guidelines:

- Aggregation—Use of the **aggregate none** command significantly increases the amount of memory required because each individual measurement is recorded, rather than just counts for each aggregation bin. When you configure aggregation, consider that more bins will require more memory.
- Buckets archive—When you configure the **buckets archive** command, consider that the more history that is kept, the more memory will be used.
- Measuring two statistics (such as both delay and jitter) will use approximately twice as much memory as measuring one.
- Separate statistics are stored for one-way source-to-destination and destination-to-source measurements, which consumes twice as much memory as storing a single set of round-trip statistics.

- The Cisco ASR 9000 Series Router supports SLA packet intervals of 100 ms and longer. If Ethernet SLA is configured, the overall combined packet rate for CCMs and SLA frames is 16000 frames-per-second in each direction, per card.
- You must define the schedule before you configure SLA probe parameters to send probes for a particular profile. It is recommended to set up the profile—probe, statistics, and schedule before any commit.

Note When the **once** keyword is used for 'send burst' ('send burst once' rather than 'send burst every'), it stops the collection of statistics with the packets that cross probe boundaries.

The following procedure provides the steps to configure Ethernet Service Level Agreement (SLA) monitoring at Layer 2.

To configure SLA, perform the following tasks:

Configuring an SLA Operation Profile

To configure a profile, perform the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet sla**
3. **profile** *profile-name* **type** {**cfm-delay-measurement** | **cfm-loopback** | **cfm-synthetic-loss-measurement**|
4. **cfm-loss-measurement**}
5. **end** or **commit**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **ethernet sla**

Example:

```
RP/0/RSP0/CPU0:router# ethernet sla
```

Enters the SLA configuration mode.

Step 3 **profile** *profile-name* **type** {**cfm-delay-measurement** | **cfm-loopback** | **cfm-synthetic-loss-measurement**|

Step 4 **cfm-loss-measurement**}

Example:

```
RP/0/RSP0/CPU0:router(config-sla)# profile  Prof1 type cfm-loopback
```

Creates an SLA operation profile and enters the SLA profile configuration mode.

Step 5 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-sla)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring a Schedule for an SLA Operation Probe in a Profile

This section describes how to configure a schedule for an SLA operation probe on an ongoing basis within an SLA profile. For information about how to configure a schedule for a limited, on-demand SLA operation, see the Configuring an On-Demand SLA Operation.

To configure a schedule for an SLA operation probe, perform the following steps beginning in SLA profile configuration mode:

SUMMARY STEPS

1. **schedule every week on** *day* [**at** *hh*:*mm*] [**for** *duration* {**seconds** | **minutes** | **hours** | **days** | **week**}] or **schedule every day** [**at** *hh*:*mm*] [**for** *duration* {**seconds** | **minutes** | **hours** | **days** | **week**}] **or schedule every** *number* {**hours** | **minutes}[first at** *hh*:*mm*[**.***ss*]] [**for** *duration* {**seconds** | **minutes** | **hours** | **days** | **week**}]
2. **end** or **commit**

DETAILED STEPS

Step 1 **schedule every week on** *day* [**at** *hh*:*mm*] [**for** *duration* {**seconds** | **minutes** | **hours** | **days** | **week**}] or **schedule every day** [**at** *hh*:*mm*] [**for** *duration* {**seconds** | **minutes** | **hours** | **days** | **week**}] **or schedule every** *number* {**hours** | **minutes}[first at** *hh*:*mm*[**.***ss*]] [**for** *duration* {**seconds** | **minutes** | **hours** | **days** | **week**}]

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof)# schedule every week on Monday at 23:30 for 1 hour
or
RP/0/RSP0/CPU0:router(config-sla-prof)# schedule every day at 11:30 for 5 minutes
or
RP/0/RSP0/CPU0:router(config-sla-prof)# schedule every 2 hours first at 13:45:01
or

RP/0/RSP0/CPU0:router(config-sla-prof)# schedule every 6 hours for 2 hours
```

Schedules an operation probe in a profile. A profile may contain only one schedule.

Note The schedule start time starts after the configuration is committed and not at the time when the operation is configured.

For information on the *schedule* command behavior and usage guidelines, see *Interface and Hardware Component Command Reference for Cisco ASR 9000 Series Routers*, chapter *Ethernet OAM Commands*.

Step 2 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof-stat-cfg)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring SLA Probe Parameters in a Profile

To configure SLA probe parameters in a profile, perform these steps beginning in SLA profile configuration mode:

SUMMARY STEPS

1. **probe**
2. **send burst** {**every** *number* {**seconds | minutes | hours}** | **once**} **packet count** *packets* **interval** *number* {**seconds | milliseconds**}
3. or

4. **send packet** {**every** *number* {**milliseconds | seconds | minutes | hours**} | **once**}
5. **packet size** *bytes* [**test pattern {hex 0xHHHHHHHH | pseudo-random**}]
6. **priority** *priority*
7. **synthetic loss calculation packets** *number*
8. **end** or **commit**

DETAILED STEPS

Step 1 **probe**

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof)# probe
```

Enters the SLA profile probe configuration mode.

Step 2 **send burst** {**every** *number* {**seconds | minutes | hours} | once**} **packet count** *packets* **interval** *number* {**seconds | milliseconds**}

Step 3 or

Step 4 **send packet** {**every** *number* {**milliseconds | seconds | minutes | hours**} | **once**}

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof-pb)# send burst every 60 seconds packet count 100 interval 100
 milliseconds
or
RP/0/RSP0/CPU0:router(config-sla-prof-pb)# send burst once packet count 2 interval 1 second
or

RP/0/RSP0/CPU0:router(config-sla-prof-pb)# send packet every 100 milliseconds
```

Configures the number and timing of packets sent by a probe in an operations profile.

Note When the **once** keyword for 'send burst' ('send burst once' rather than 'send burst every') is used, it stops the collection of statistics with the packets that cross probe boundaries.

Step 5 **packet size** *bytes* [**test pattern {hex 0xHHHHHHHH | pseudo-random**}]

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof-pb)# packet size 9000
```

Configures the minimum size (in bytes) for outgoing probe packets, including padding when necessary. Use the test pattern keyword to specify a hexadecimal string to use as the padding characters, or a pseudo-random bit sequence. The default padding is 0's. The packet size can be configured for SLM, loopback, and DMM/R probes.

Step 6 **priority** *priority*

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof-pb)# priority 7
```

Configures the priority of outgoing SLA probe packets.

If the operation is running on an interface, which matches tagged traffic, then a priority value must be configured for the probe. This priority value must match the "on-the-wire" CoS value of the packets to be counted (after any tag rewrites).LMM packets are sent with this priority value as the CoS-value, and LMR packets must be received with the same CoS-value; otherwise, all LMRs are dropped. Note that this is the case even when aggregate counters are being collected.

If the operation is running on an interface which matches untagged traffic, then configuring a priority value is not permitted. In this case, only aggregate counters can be collected. When configuring data-loss measurement operations, configuration must also be applied to allocate the correct packet counters (matching the CoS values to be collected) on the interface, using the "loss-measurement counters" configuration under the MEP properties submode.

Step 7 **synthetic loss calculation packets** *number*

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof-pb)# synthetic loss calculation packets 25
```

Configures the number of packets that must be used to make each FLR calculation in the case of synthetic loss measurements. This item can only be configured for packet types that support synthetic loss measurement.

An FLR value is calculated for each discrete block of packets. For instance, if a value of 10 is configured, the first FLR value would be calculated based on packets 0 - 9 and the second FLR value based on packets 10 - 19, and so on.

Step 8 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof-pb)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring SLA Statistics Measurement in a Profile

The Ethernet SLA feature supports measurement of one-way and two-way delay and jitter statistics, and one-way FLR statistics.

Before you begin

To configure one-way delay or jitter measurements, you must first configure the **profile (SLA)** command using the **type cfm-delay-measurement** form of the command.

For valid one-way delay results, you need to have both local and remote devices time synchronized. In order to do this, you must select sources for frequency and time-of-day (ToD).

Frequency selection can be between any source of frequency available to the router, such as: BITS, GPS, SyncE or PTP. The ToD selection is between the source selected for frequency and PTP or DTI. Note that NTP is not sufficient.

For more information about frequency and time synchronization, refer to the *Configuring Frequency Synchronization on the Cisco ASR 9000 Series Router* and the *Configuring PTP on the Cisco ASR 9000 Series Router* modules in the *Cisco ASR 9000 Series Aggregation Services Router System Management Configuration Guide*.

Restrictions

One-way delay and jitter measurements are not supported by cfm-loopback profile types.

To configure SLA statistics measurement in a profile, perform these steps beginning in SLA profile configuration mode:

SUMMARY STEPS

1. **statistics measure** {**one-way-delay-ds | one-way-delay-sd | one-way-jitter-ds | one-way-jitter-sd | round-trip-delay | round-trip-jitter | one-way-loss-ds | one-way-loss-sd**}
2. **aggregate** {**bins** *count* **width** *width* | **none**}
3. **buckets size** *number* **probes**
4. **buckets archive** *number*
5. **end** or **commit**

DETAILED STEPS

Step 1 **statistics measure** {**one-way-delay-ds | one-way-delay-sd | one-way-jitter-ds | one-way-jitter-sd | round-trip-delay | round-trip-jitter | one-way-loss-ds | one-way-loss-sd**}

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof)# statistics measure round-trip-delay
```

Enables the collection of SLA statistics, and enters SLA profile statistics configuration mode.

Step 2 **aggregate** {**bins** *count* **width** *width* | **none**}

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof-stat-cfg)# aggregate bins 100 width 10000
```

Configures the size and number of bins into which to aggregate the results of statistics collection. For delay measurements and data loss measurements, the default is that all values are aggregated into 1 bin. For synthetic loss measurements, the default is aggregation disabled.

- For delay and jitter measurements, you can configure a width value from 1 to 10000 milliseconds, if the number of bins is at least 2.

- For data loss and synthetic loss measurements, you can configure a width value from 1 to 100 percentage points, if the number of bins is at least 2.

Step 3 **buckets size** *number* **probes**

Configures the size of the buckets in which statistics are collected.

Step 4 **buckets archive** *number*

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof-stat-cfg)# buckets archive 50
```

Configures the number of buckets to store in memory.

Step 5 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof-stat-cfg)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Example

This example displays aggregate bins configured with a range of 10 milliseconds:

```
Router# show ethernet sla statistics detail
Tue Sep 28 08:00:57.527 PDT
Source: Interface GigabitEthernet0/0/0/2, Domain dom1
Destination: Target MAC Address 0012.0034.0056
================================================================================
Profile 'test', packet type 'cfm-delay-measurement'
Scheduled to run every 1min first at 00:00:31 UTC for 10s

Round Trip Delay
~~~~~~~~~~~~~~~~
1 probes per bucket
```

```
No stateful thresholds.

Bucket started at 08:00:32 PDT Tue 28 September 2021 lasting 10s
    Pkts sent: 9; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                  Misordered: 1 (11.1%); Duplicates: 0 (0.0%)
    Result count: 9
    Min: 0.000ms, occurred at 08:00:32 PDT Tue 28 September 2021
    Max: 0.000ms, occurred at 08:00:32 PDT Tue 28 September 2021
    Mean: 0.000ms; StdDev: 0.000ms

    Results suspect due to a probe starting mid-way through a bucket

    Bins:
    Range           Samples  Cum. Count     Mean
    -----------  ----------  ----------  -------
     0 to 10 ms  9 (100.0%)  9 (100.0%)  0.000ms
    10 to 20 ms  0   (0.0%)  9 (100.0%)        -
    20 to 30 ms  0   (0.0%)  9 (100.0%)        -
    30 to 40 ms  0   (0.0%)  9 (100.0%)        -
    > 40     ms  0   (0.0%)  9 (100.0%)        -
```

Configuring an SLA Operation

This section describes how to configure an ongoing SLA operation on a MEP using an SLA profile.

SUMMARY STEPS

1. **interface** [**FastEthernet**
2. **ethernet cfm**
3. **mep domain** *domain-name* **service** *service-name* **mep-id** *id-number*
4. **sla operation profile** *profile-name* **target** {**mep-id** *id* | **mac-address** *mac-address*}
5. **end** or **commit**

DETAILED STEPS

Step 1 **interface** [**FastEthernet**

Example:

```
RP/0/RSP0/CPU0:router(config-if)# interface gigabitethernet 0/1/0/1
```

Physical interface or virtual interface.

Note
- Use the **show interfaces** command to see a list of all interfaces currently configured on the router.

For more information about the syntax for the router, use the question mark (**?**) online help function.

Step 2 **ethernet cfm**

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ethernet cfm
```

Enters interface CFM configuration mode.

Step 3 **mep domain** *domain-name* **service** *service-name* **mep-id** *id-number*

Example:

```
RP/0/RSP0/CPU0:router(config-if-cfm)# mep domain Dm1 service Sv1 mep-id 1
```

Creates a MEP on an interface and enters interface CFM MEP configuration mode.

Step 4 **sla operation profile** *profile-name* **target** {**mep-id** *id* | **mac-address** *mac-address*}

Example:

```
RP/0/RSP0/CPU0:router(config-if-cfm-mep)# sla operation profile Profile_1 target mac-address
01:23:45:67:89:ab
```

Creates an operation instance from a MEP to a specified destination.

Step 5 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-sla-prof-stat-cfg)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring an On-Demand SLA Operation

The Cisco ASR 9000 Series Router supports configuration of on-demand SLA operations to run on an as-needed basis for a finite period of time.

This section includes the following topics:

Configuration Guidelines

When you configure on-demand SLA operations, consider the following guidelines:

- Each MEP supports up to 50 on-demand operations.
- Each card supports up to 250 on-demand operations.

- On-demand Ethernet SLA operations can be run in addition to any other ongoing scheduled SLA operations that you might have configured, and use similar amounts of CPU and router memory. When configuring an on-demand Ethernet SLA operation, you should consider your existing SLA operation configuration and the potential impact of additional packet processing to your normal operations.
- If you do not specify a schedule for the on-demand operation, the probe defaults to running one time beginning two seconds from the execution of the command, and runs for a ten-second duration.
- If you do not specify the statistics for the probe to measure, it defaults to measuring all statistics, inlcuding these statistics by probe type:
  - CFM loopback—Two-way delay and jitter is measured by default.
  - CFM delay measurement—One-way delay and jitter in both directions, in addition to two-way delay and jitter is measured by default.
  - CFM synthetic loss measurement—One-way FLR in both directions is measured by default.
- The default operation mode is synchronous, where progress of the operation is reported to the console and the output of the statistics collection is displayed.

Note When the **once** keyword is used for 'send burst' ('send burst once' rather than 'send burst every'), it stops the collection of statistics with the packets that cross probe boundaries.

Configuring an On-Demand Ethernet SLA Operation for CFM Delay Measurement

To configure an on-demand Ethernet SLA operation for CFM delay measurement, use the following command in privileged EXEC configuration mode:

ethernet sla on-demand operation type cfm-delay-measurement probe [**priority** *number*] [**send** {**packet** {**once** | **every** *number* {**milliseconds** | **seconds** | **minutes** | **hours**}} | **burst** {**once** | **every** *number* {**seconds** | **minutes** | **hours**}} **packet count** *number* **interval** *number* {**milliseconds** | **seconds**}] **domain** *domain-name* **source interface** *type interface-path-id* **target** {**mac-address** *H.H.H.H* | **mep-id** *id-number*} [**statistics measure** {**one-way-delay-ds** | **one-way-jitter-ds** | **one-way-jitter-sd** | **round-trip-delay** | **round-trip-jitter**}][**aggregate** {**none** | **bins** *number* **width** *milliseconds*}] [**buckets** {**archive** *number* **probes**| **size** *number* **probes**}] [**schedule** {**now** | **at** *hh*:*mm*[.*ss*] [*day* [*month* [*year*]]] | **in** *number* {**seconds** | **minutes** | **hours**}}[**for** *duration* {**seconds** | **minutes** | **hours**}][**repeat every** *number* {**seconds** | **minutes** | **hours**} **count** *probes*]] [**asynchronous**] `RP/0/RSP0/CPU0:router# ethernet sla on-demand operation type cfm-delay-measurement probe domain D1 source interface TenGigE 0/6/1/0 target mep-id 100`	Configures an on-demand Ethernet SLA for CFM delay measurement. The example shows a minimum configur specifies the local domain and source int target MEP, using the following defaults: • Send a burst once for a packet count interval of 1 second (10-second prob • Use default class of service (CoS) for interface. • Measure all statistics, including both and round-trip delay and jitter statist • Aggregate statistics into one bin. • Schedule now. • Display results on the console.

Configuring an On-Demand Ethernet SLA Operation for CFM Loopback

To configure an on-demand Ethernet SLA operation for CFM loopback, use the following command in privileged EXEC configuration mode:

ethernet sla on-demand operation type cfm-loopback probe [**packet size** *bytes* [**test pattern** {**hex 0x***HHHHHHHH* | **pseudo-random**}]] [**priority** *number*] [**send** {**packet** {**once** | **every** *number* {**milliseconds** | **seconds** | **minutes** | **hours**}} | **burst** {**once** | **every** *number* {**seconds** | **minutes** | **hours**}} **packet count** *number* **interval** *number* {**milliseconds** | **seconds**}] **domain** *domain-name* **source interface** *type interface-path-id* **target** {**mac-address** *H.H.H.H* | **mep-id** *id-number*} [**statistics measure** {**round-trip-delay** | **round-trip-jitter**}][**aggregate** {**none** | **bins** *number* **width** *milliseconds*}][**buckets** {**archive** *number* **probes** | **size** *number* **probes**}] [**schedule** {**now** | **at** *hh***:***mm*[**.***ss*] [*day* [*month* [*year*]]] | **in** *number* {**seconds** | **minutes** | **hours**}}[**for** *duration* {**seconds** | **minutes** | **hours**}][**repeat every** *number* {**seconds** | **minutes** | **hours**} **count** *probes*]] [**asynchronous**] `RP/0/RSP0/CPU0:router# ethernet sla on-demand operation type cfm-loopback probe packet size 1500 domain D1 source interface TenGigE 0/6/1/0 target mep-id 100`	Configures an on-demand Etherne operation for CFM loopback. The example shows a minimum c but specifies the option of a minin size, and specifies the local domai interface and target MEP, using th defaults: • Send a burst once for a packe and interval of 1 second (10-s • Use default test pattern of 0's • Use default class of service (egress interface. • Measure all statistics. • Aggregate statistics into one • Schedule now. • Display results on the consol

Configuring an On-Demand Ethernet SLA Operation for CFM Synthetic Loss Measurement

To configure an on-demand Ethernet SLA operation for CFM synthetic loss measurement, use this command in privileged EXEC configuration mode:

ethernet sla on-demand operation type cfm-synthetic-loss-measurement probe [**priority** *number*] [**send** {**packet** {**once** | **every** *number* {**milliseconds** | **seconds** | **minutes** | **hours**}} | **burst** {**once** | **every** *number* {**seconds** | **minutes** | **hours**}} **packet count** *number* **interval** *number* {**milliseconds** | **seconds**}] **domain** *domain-name* **source interface** *type interface-path-id* **target** {**mac-address** *H.H.H.H* | **mep-id** *id-number*} [**synthetic loss calculation packets** *number*] [**statistics measure** {**one-way-loss-ds** | **one-way-loss-sd**}][**aggregate** {**none** | **bins** *number* **width** *milliseconds*}] [**buckets** {**archive** *number* **probes**| **size** *number* **probes**}] [**schedule** {**now** | **at** *hh***:***mm*[**.***ss*] [*day* [*month* [*year*]]] | **in** *number* {**seconds** | **minutes** | **hours**}}[**for** *duration* {**seconds** | **minutes** | **hours**}][**repeat every** *number* {**seconds** | **minutes** | **hours**} **count** *probes*]] [**asynchronous**] `RP/0/RSP0/CPU0:router# ethernet sla on-demand operation type cfm-synthetic-loss-measurement probe domain D1 source interface TenGigE 0/6/1/0 target mac-address 2.3.4`	Configures an on-demand Ethernet SL for CFM synthetic loss measurement. The example shows a minimum confi specifies the local domain and source target MEP.

Verifying SLA Configuration

To verify SLA configuration, use one or more of these commands:

show ethernet sla configuration-errors [**domain** *domain-name*] [**interface** *interface-path-id*] [**profile** *profile-name*]	Displays information about errors that are preventing configured SLA operations from becoming active, as well as any warnings that have occurred.
show ethernet sla operations [**detail**] [**domain** *domain-name*] [**interface** *interface-path-id*] [**profile** *profile-name*]	Displays information about configured SLA operations.

Bit Error Rate

In network transmission, data streaming over communication channels is susceptible to unplanned alterations during transmission. Such alterations are due to noise, interference, or synchronization errors. The number of bits thus received with alterations is measured as the number of bit errors.

Bit Error Rate (BER) is the number of bit errors per unit time or time window. For example, consider a scenario where the bit rate reaching the receiver is 10 bits per second, and the bit error is 1 bit per second. In this example, the BER is bit errors/unit time or time window = 1 bit/second.

Using this feature, you can test cables and diagnose signal problems in the field. You can display and analyze the total number of error bits transmitted and the total received on the link. Your router supports BER on 10/40/100 GE interfaces.

The error range measurement that your router supports is 10E-8 through 10E-12 bits, where E = *10^. Thus, the error range is from:

10*10^ -8 = 10 x 0.00000001 = 0.0000001 bits

through

10*10^ -12 = 10 x 0.000000000001 = 0.00000000001 bits

Bit errors usually occur because of:

- Faulty or bad cables
- Loose cable connections at one or both ends

How is Bit Error Rate Measured?

BER algorithm polls the hardware counters periodically for bit errors, every 500ms.

For 40 GE and 100GE interfaces, your router uses a physical coding sublayer (PCS) bit interleaved parity (BIP) error counter.

For 10 GE interfaces, your router employs a sync header error counter. (BIP counters aren't supported for 10GE interfaces.)

What are Bit Error Rate Error States and Thresholds?

BER has the following error conditions for which you must configure threshold values at the interface:

- Signal Degradation (SD): there’s a reduction in the signal quality but no loss of service, referred to as 'graceful error'.
- Signal Failure (SF): there's a loss of service because of a link-state change, referred to as 'catastrophic error'. The SF threshold state is enabled by default.

A switch uses the BER threshold value to detect an increased error rate before performance degradation seriously affects traffic. If the polling indicates the reaching of the error threshold value:

- For SD BER: the console generates an IOS message.
- For SF BER: the console generates an IOS message. Plus, you can bring down the interface transmission at the device under test (DUT) end.

Sliding Window for Polling

BER employs the concept of a sliding window to measure bit performance while polling happens in a small-length sequence of several windows. Here, 'window' refers to the BIP period or duration defined for different threshold levels. Consider a scenario where the BIP period is 2.5 seconds and the software polls the hardware counter every 500 ms. In this example, the 2.5 seconds BIP period is complete after five polls, and the window completely deploys. For the next round of polling, the window slides to the following sequence, thus ensuring better error performance while consuming lesser memory.

Alarm Raise

If errors above the configured threshold accumulate in the first poll, an alarm is raised right away instead of waiting for the completion of the BIP period. For example, if there are errors above the threshold value in the first poll of 500 ms, an alarm is raised immediately and not after completing 2.5 seconds (five polls) of the BIP period.

Alarm Clearance

The SD and SF alarm clearance is automatic once the error value is below a certain threshold level. Your router uses the configured error threshold value to measure the errors and generates IOS messages at that threshold.

Your router waits till the last poll of window deployment before clearing the alarm. The alarm is cleared as soon as the error value goes below the configured threshold value. This ensures that no new errors accumulate during the last poll of the completed window, which might keep the error count above the threshold.

Configure BER

To configure BER thresholds:

1. Enter the configuration mode for your interface.
2. Enable the Signal Degrade Bit Error Rate (SD-BER) on the interface.

Note SD-BER is disabled by default.

3. Configure the SD-BER threshold.
4. Configure the Signal Fail Bit Error Rate (SF-BER) threshold.

Note SF-BER is enabled by default.

5. Enable remote fault signaling when SF BER is triggered.

Note Remote signaling for SF BER is disabled by default.

```
Router#config
Router(config)#int TenGigE 0/1/0/3
/*Enable SD-BER*/
Router(config-if)#report sd-ber
/*Configure SD-BER threshold*/
Router(config-if)#threshold sd-ber 12
/*Configure SF-BER threshold*/
Router(config-if)#threshold sf-ber 8
Router(config-if)#commit
Router(config-if)#exit
```

Running Configuration

```
int TenGigE 0/1/0/3
!
 report sd-ber
!
 threshold sd-ber 12
!
 threshold sf-ber 8
!
!
```

Verification

Run the **show controllers <interface> all** command to verify the BER default value as well as the configured threshold values.

```
BER monitoring:
Signal Degrade: 1e-11 (report-alarm)
Signal Fail: 1e-9 (report-alarm, signal-rf)
Current SD BER: 0
Current SF BER: 0

BER-SD Threshold: 1e-12
BER-SD Report: Enabled
BER-SF Threshold: 1e-8
BER-SF Report: Not configured (Enabled)
```

Cyclic Redundancy Check

The Cyclic Redundancy Check (CRC) based Bit Error Ratio (BER) is an active measure of the error rate in a communication system that utilizes CRC as an error detection method. CRC is a widely adopted error-detection technique that ensures the integrity of data transmissions. It involves appending a fixed number of check bits to the transmitted data, which are then utilized to identify any errors that may occur during the transmission process.

The CRC based BER calculates the number of errors in a received message, divided by the total number of transmitted bits. This measurement allows you to evaluate the quality of the communication system and identify any potential issues that require attention. A low BER indicates a high-quality system with minimal errors, while a high BER signifies a higher error rate and potential concerns with the communication system.

BER represents the number of bit errors per unit of time. The BER ratio denotes the number of Cyclic Redundancy Check (CRC) errors divided by the total number of transferred bits during a specific time interval. Furthermore, BER utilizes CRC for error detection within a network, enabling you to promptly identify and address faulty links.

The CRC based BER feature is available on the following line cards: [List line cards here].

- A9K-24X10GE-1G-SE
- A9K-24X10GE-1G-TR
- A9K-48X10GE-1G-SE
- A9K-48X10GE-1G-TR
- A99-48X10GE-1G-SE
- A99-48X10GE-1G-TR

Configure CRC BER

```
Router#config
Router(config)#int TenGigE 0/1/0/3
/*Enable CRC BER
Router(config-if)#report crc-ber
/*Enable SD-BER*/
Router(config-if)#report sd-ber
/*Configure SD-BER threshold*/
Router(config-if)#threshold sd-ber 12
/*Configure SF-BER threshold*/
Router(config-if)#threshold sf-ber 8
/*Enable crc-ber autorecovery*/
Router(config-if)#crc-ber auto-recover 2
Router(config-if)#commit
Router(config-if)#exit
```

Running Configuration

```
interface TenGigE0/1/0/3
 ipv4 address 11.1.13.1 255.255.255.0
 report crc-ber    ---- > mandatory config to report crc-ber
 report sd-ber     ----- > To report sd-ber
 threshold sd-ber 12  --- > sd-ber threshold set to 12
 threshold sf-ber 8   ---- > sf-ber threshold set to 8
 crc-ber auto-recover 2     ---- > ber is cleared within configured time
```

Verification

Run the **show controllers <interface> all** command to verify the BER default value as well as the configured threshold values.

```
RP/0/RSP0/CPU0:ios#show controllers tenGigE0/1/0/3 all | inc BER
BER-SD Threshold: 1e-6
    BER-SD Report: Enabled
    BER-SF Threshold: 1e-7
```

```
BER-SF Report: Not configured (Enabled)
BER-CRC Report: Enabled
```

Associated Commands

- report crc-ber
- crc-ber auto-recover
- report sd-ber
- report sf-ber disable
- threshold sd-ber
- threshold sf-ber

Configuring Ethernet LMI

To configure Ethernet LMI, complete the following tasks:

Prerequisites for Configuring E-LMI

Before you configure E-LMI on the Cisco ASR 9000 Series Router, be sure that you complete the following requirements:

- Identify the local and remote UNIs in your network where you want to run E-LMI, and define a naming convention for them.
- Enable E-LMI on the corresponding CE interface link on a device that supports E-LMI CE operation, such as the Cisco Catalyst 3750 Metro Series Switches.

Restrictions for Configuring E-LMI

When configuring E-LMI, consider the following restrictions:

- E-LMI is not supported on subinterfaces or bundle interfaces. E-LMI is configurable on Ethernet physical interfaces only.
- E-LMI is not supported on nV satellite access interfaces when the inter-chassis links are configured as a bundle.

Creating EVCs for E-LMI

EVCs for E-LMI on the Cisco ASR 9000 Series Router are established by first configuring EFPs (Layer 2 subinterfaces) on the local UNI physical Ethernet interface link to the CE where E-LMI will be running, and also on the remote UNI link. Then, the EFPs need to be assigned to an L2VPN bridge domain to create the EVC.

To create EVCs, complete the following tasks:

Configuring EFPs

This section describes the basic configuration of an EFP. For more information about configuration of other supported Layer 2 services, see the *Cisco ASR 9000 Series Aggregation Services Routers L2VPN and Ethernet Services Configuration Guide*.

To configure an EFP, complete these tasks:

SUMMARY STEPS

1. **configure**
2. **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id.subinterface* **l2transport**
3. **encapsulation dot1q** *vlan-id* [**, untagged** | **,** *vlan-id* | **–***vlan-id*] [**exact** | **ingress source-mac** *mac-address* | **second-dot1q** *vlan-id*]
4. **end** or **commit**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id.subinterface* **l2transport**

Example:

```
RP/0/RSP0/CPU0:router(config)# interface gigabitethernet 0/0/0/0.0 l2transport
```

Creates a VLAN subinterface in Layer 2 transport mode and enters Layer 2 subinterface configuration mode.

Step 3 **encapsulation dot1q** *vlan-id* [**, untagged** | **,** *vlan-id* | **–***vlan-id*] [**exact** | **ingress source-mac** *mac-address* | **second-dot1q** *vlan-id*]

Example:

```
RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 1-20
```

Defines the matching criteria to map 802.1Q frames ingress on an interface to the appropriate service instance.

Step 4 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-subif)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring a Bridge Group and Assigning EFPs to a Bridge Domain

To configure a bridge group and assign EFPs to a bridge domain to create an EVC, complete the following steps:

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **interface** [**GigabitEthernet | TenGigE**] *interface-path-id.subinterface*
6. **end** or **commit**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group BG1
```

Creates a bridge group and enters L2VPN bridge group configuration mode.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain BD1
```

Creates a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **interface** [**GigabitEthernet | TenGigE**] *interface-path-id.subinterface*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# interface GigabitEthernet 0/0/0/0.0
```

Associates the EFP (EVC) with the specified bridge domain and enters L2VPN bridge group bridge domain attachment circuit configuration mode, where *interface-path-id* is specified as the *rack*/*slot*/*module*/*port* location of the interface and **.***subinterface* is the subinterface number.

Repeat this step for as many EFPs (EVCs) as you want to associate with the bridge domain.

Step 6 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# end
```

or

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Ethernet CFM for E-LMI

The Cisco ASR 9000 Series Router uses Ethernet CFM to monitor EVC status for E-LMI. To use CFM for E-LMI, a CFM maintenance domain and service must be configured on the router and the EFPs must be configured as CFM Up MEPs.

To configure Ethernet CFM for E-LMI, complete the following tasks:

Configuring Ethernet CFM

The minimum configuration to support E-LMI using Ethernet CFM is to configure a CFM maintenance domain and service on the router. Other CFM options can also be configured.

For more information about the tasks to configure Ethernet CFM, see the Configuring Ethernet CFM.

Configuring EFPs as CFM Up MEPs

This section describes the minimum tasks required to configure EFPs as CFM MEPs. For more information about configuring CFM MEPs, see the Configuring CFM MEPs.

To configure EFPs as CFM MEPs, complete the following tasks for each E-LMI EFP:

SUMMARY STEPS

1. **configure**
2. **interface gigabitethernet** *interface-path-id.subinterface* **l2transport**
3. **ethernet cfm**
4. **mep domain** *domain-name* **service** *service-name* **mep-id** *id-number*
5. **end** or **commit**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface gigabitethernet** *interface-path-id.subinterface* **l2transport**

Example:

```
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet0/0/0/0.0 l2transport
```

Enters Layer 2 subinterface configuration mode for the EFP.

Step 3 **ethernet cfm**

Example:

```
RP/0/RSP0/CPU0:router(config-subif)# ethernet cfm
```

Enters Ethernet CFM interface configuration mode.

Step 4 **mep domain** *domain-name* **service** *service-name* **mep-id** *id-number*

Example:

```
RP/0/RSP0/CPU0:router(config-if-cfm)# mep domain GLOBAL service CustomerA mep-id 22
```

Creates a MEP on an interface and enters interface CFM MEP configuration mode.

Step 5 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-if-cfm-mep)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring UNI Names on the Physical Interface

It is recommended that you configure UNI names on the physical interface links to both the local and remote UNIs to aid in management for the E-LMI protocol. To configure UNI names, complete the following tasks on the physical interface links to both the local and remote UNIs:

SUMMARY STEPS

1. **configure**
2. **interface [GigabitEthernet | TenGigE]** *interface-path-id*
3. **ethernet uni id** *name*
4. **end** or **commit**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface [GigabitEthernet | TenGigE]** *interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router(config)# interface gigabitethernet 0/0/0/0
```

Enters interface configuration mode for the physical interface.

Step 3 **ethernet uni id** *name*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ethernet uni id PE1-CustA-Slot0-Port0
```

Specifies a name (up to 64 characters) for the Ethernet UNI interface link.

Step 4 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Enabling E-LMI on the Physical Interface

The Cisco ASR 9000 Series Router supports the E-LMI protocol only on physical Ethernet interfaces. To enable E-LMI, complete the following tasks on the physical Ethernet interface link to the local UNI:

SUMMARY STEPS

1. **configure**
2. **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id*
3. **ethernet lmi**
4. **end** or **commit**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router# interface gigabitethernet 0/0/0/0
```

Enters interface configuration mode for the physical interface.

Step 3 **ethernet lmi**

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ethernet lmi
```

Enables Ethernet Local Managment Interface operation on an interface and enters interface Ethernet LMI configuration mode.

Step 4 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-if-lmi)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring the Polling Verification Timer

The MEF T392 Polling Verification Timer (PVT) specifies the allowable time between transmission of a STATUS message and receipt of a STATUS ENQUIRY from the UNI-C before recording an error. The default value is 15 seconds.

To modify the default value or disable the PVT altogether, complete the following tasks:

SUMMARY STEPS

1. **configure**
2. **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id*
3. **ethernet lmi**
4. **polling-verification-timer** {*interval* | **disable**}
5. **end** or **commit**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router# interface gigabitethernet 0/0/0/0
```

Enters interface configuration mode for the physical interface.

Step 3 **ethernet lmi**

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ethernet lmi
```

Enables Ethernet Local Managment Interface operation on an interface and enters interface Ethernet LMI configuration mode.

Step 4 **polling-verification-timer** {*interval* | **disable**}

Example:

```
RP/0/RSP0/CPU0:router(config-if-lmi)# polling-verification-timer 30
```

Sets or disables the MEF T392 Polling Verification Timer for E-LMI operation, which specifies the allowable time (in seconds) between transmission of a STATUS message and receipt of a STATUS ENQUIRY from the UNI-C before recording an error. The default is 15.

Step 5 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-if-lmi)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring the Status Counter

The MEF N393 Status Counter value is used to determine E-LMI operational status by tracking receipt of consecutive good packets or successive expiration of the PVT on packets. The default counter is four, which means that while the E-LMI protocol is in Down state, four good packets must be received consecutively to change the protocol state to Up, or while the E-LMI protocol is in Up state, four consecutive PVT expirations must occur before the state of the E-LMI protocol is changed to Down on the interface.

To modify the status counter default value, complete the following tasks:

SUMMARY STEPS

1. **configure**
2. **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id*
3. **ethernet lmi**
4. **status-counter** *threshold*
5. **end** or **commit**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router# interface gigabitethernet 0/0/0/0
```

Enters interface configuration mode for the physical interface.

Step 3 **ethernet lmi**

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ethernet lmi
```

Enables Ethernet Local Managment Interface operation on an interface and enters interface Ethernet LMI configuration mode.

Step 4 **status-counter** *threshold*

Example:

```
RP/0/RSP0/CPU0:router(config-if-lmi)# status-counter 5
```

Sets the MEF N393 Status Counter value that is used to determine E-LMI operational status by tracking receipt of consecutive good and bad packets from a peer. The default is 4.

Step 5 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-if-lmi)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Disabling Syslog Messages for E-LMI Errors or Events

The E-LMI protocol tracks certain errors and events whose counts can be displayed using the **show ethernet lmi interfaces** command.

To disable syslog messages for E-LMI errors or events, complete the following tasks:

SUMMARY STEPS

1. **configure**
2. **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id*
3. **ethernet lmi**
4. **log** {**errors** | **events**} **disable**
5. **end** or **commit**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router# interface gigabitethernet 0/0/0/0
```

Enters interface configuration mode for the physical interface.

Step 3 **ethernet lmi**

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ethernet lmi
```

Enables Ethernet Local Managment Interface operation on an interface and enters interface Ethernet LMI configuration mode.

Step 4 **log** {**errors** | **events**} **disable**

Example:

```
RP/0/RSP0/CPU0:router(config-if-lmi)# log events disable
```

Turns off syslog messages for E-LMI errors or events.

Step 5 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-if-lmi)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.

- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Disabling Use of the Cisco-Proprietary Remote UNI Details Information Element

To provide additional information within the E-LMI protocol, the Cisco IOS XR software implements a Cisco-proprietary information element called Remote UNI Details to send information to the CE about remote UNI names and states. This information element implements what is currently an unused identifier from the E-LMI MEF 16 specification.

To disable use of the Remote UNI Details information element, complete the following tasks:

SUMMARY STEPS

1. **configure**
2. **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id*
3. **ethernet lmi**
4. **extension remote-uni disable**
5. **end** or **commit**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface** [**GigabitEthernet** | **TenGigE**] *interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router# interface gigabitethernet 0/0/0/0
```

Enters interface configuration mode for the physical interface.

Step 3 **ethernet lmi**

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ethernet lmi
```

Enables Ethernet Local Managment Interface operation on an interface and enters interface Ethernet LMI configuration mode.

Step 4 **extension remote-uni disable**

Example:

```
RP/0/RSP0/CPU0:router(config-if-lmi)# extension remote-uni disable
```

Disables transmission of the Cisco-proprietary Remote UNI Details information element in E-LMI STATUS messages.

Step 5 **end** or **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-if-lmi)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Verifying the Ethernet LMI Configuration

Use the **show ethernet lmi interfaces detail** command to display the values for the Ethernet LMI configuration for a particular interface, or for all interfaces. The following example shows sample output for the command:

```
RP/0/RSP0/CPU0:router# show ethernet lmi interfaces detail
Interface: GigabitEthernet0/0/0/0
  Ether LMI Link Status: Up
  UNI Id: PE1-CustA-Slot0-Port0
  Line Protocol State: Up
  MTU: 1514 (1 PDU reqd. for full report)
  CE-VLAN/EVC Map Type: Bundling (1 EVC)
  Configuration: Status counter 4, Polling Verification Timer 15 seconds
  Last Data Instance Sent: 0
  Last Sequence Numbers: Sent 0, Received 0

  Reliability Errors:
    Status Enq Timeouts                 0 Invalid Sequence Number            0
    Invalid Report Type                 0

  Protocol Errors:
    Malformed PDUs                      0 Invalid Procotol Version           0
    Invalid Message Type                0 Out of Sequence IE                 0
    Duplicated IE                       0 Mandatory IE Missing               0
    Invalid Mandatory IE                0 Invalid non-Mandatory IE           0
    Unrecognized IE                     0 Unexpected IE                      0

  Full Status Enq Received     never       Full Status Sent         never
  PDU Received                 never       PDU Sent                 never
  LMI Link Status Changed   00:00:03 ago   Last Protocol Error      never
```

```
Counters cleared             never

Sub-interface: GigabitEthernet0/0/0/0.0
  VLANs: 1-20
  EVC Status: Active
  EVC Type: Point-to-Point
  OAM Protocol: CFM
    CFM Domain: Global (level 5)
    CFM Service: CustomerA
  Remote UNI Count: Configured = 1, Active = 1

  Remote UNI Id                                                  Status
  -------------                                                  ------
  PE1-CustA-Slot0-Port1                                          Up
```

Troubleshooting Tips for E-LMI Configuration

This section describes some basic information for troubleshooting your E-LMI configuration in the following topics:

Ethernet LMI Link Status Troubleshooting

The E-LMI protocol operational status is reported in the “Ether LMI Link Status” or “ELMI state” fields in the output of forms of the **show ethernet lmi interfaces** command. To investigate a link status other than “Up,” consider the following guidelines:

- Unknown (PVT disabled)—Indicates that the Polling Verification Timer has been configured as disabled, so no status information can be provided. To see an “Up” or “Down” status, you must enable the PVT. For more information, see the Configuring the Polling Verification Timer.
- Down—The E-LMI link status can be Down for the following reasons:
  - The PVT has timed out the number of times specified by the **status-counter** command. This indicates that STATUS ENQUIRY messages have not been received from the CE device. This can be for the following reasons:

    — The CE device is not connected to the PE device. Check that the CE device is connected to the interface on which E-LMI is enabled on the PE device.

    — The CE device is not sending Status Enquiries. Check that E-LMI is enabled on the CE interface which is connected to the PE device.

    — Protocol errors are causing the PVT to expire. The PVT is only reset when a valid (unerrored) STATUS ENQUIRY message is received.
  - The Line Protocol State is “Down” or “Admin Down.”
  - The protocol has not yet started on the interface because it does not have useful information to provide, such as the UNI Id or details about EVCs. This is a symptom of provisioning misconfiguration.

Note If the protocol is started, then E-LMI still responds to STATUS ENQUIRY messages when it is in “Down” state.

Ethernet LMI Line Protocol State Troubleshooting

The E-LMI line protocol state is reported in the “Line Protocol State” or “LineP State” fields in the output of forms of the **show ethernet lmi interfaces** command. The line protocol state is the state of the E-LMI protocol on the physical interface.

To investigate a line protocol state other than Up, consider the following guidelines:

- Admin-Down—The interface is configured with the **shutdown** command. Use the **no shutdown** command to bring the interface up.
- Down—Indicates a fault on the interface. Run the **show interfaces** command to display both the interface state and the interface line protocol state for more information, and take the following actions to investigate further:
  - If both states are Down, this suggests a physical problem with the link (for example, the cable is not plugged into either the PE or CE device).
  - If the interface state is Up but the line protocol state is Down, this suggests that an OAM protocol has brought the line protocol state down due to a fault. Use the **show efd interface** command for more information.

Ethernet LMI Error Counter Troubleshooting

The **show ethernet lmi interfaces** command displays two sections of error counters:

- Reliability Errors—Can indicate that messages are being lost between the PE and CE devices. The timers in the last block of the output should indicate that messages are being sent and received by the PE device.
- Protocol Errors—Indicates that the CE device is sending packets to the PE device, but the PE does not understand those packets. This suggests an incorrect configuration of the E-LMI protocol on the CE side, or corruption of the packets on the path between the CE and PE. E-LMI packets have a strictly defined structure in the MEF 16 standard, and any deviation from that results in a protocol error. The PE will not respond to any packets that are malformed and result in a protocol error.

Immediately after configuring E-LMI, all of the error counters should be zero, with the possible exception of the Status Enq Timeouts counter. The Status Enq Timeouts counter can be non-zero if the E-LMI protocol was started on the PE interface before being started on the corresponding CE interface. However, once the protocol is started on both devices, this counter should stop increasing.

If the Status Enq Timeouts counter is non-zero and is increasing, this indicates that enquiries are not being received from the CE device. This can be due to the following conditions:

- The CE device is not connected or not sending STATUS ENQUIRY messages. For more information, see also the Ethernet LMI Link Status Troubleshooting.
- The Polling Timer on the CE device is configured to a value greater than the PVT on the PE device. Verify that the value of the **polling-verification-timer** command on the PE device is larger than the value of the CE’s Polling Timer.

For more information, see also the documentation for the show ethernet lmi interfaces command in the *Cisco ASR 9000 Aggregation Services Router Interfaces and Hardware Component Command Reference*.

Ethernet LMI Remote UNI Troubleshooting

Information about the Remote UNIs is reported in the output of the **show ethernet lmi interfaces detail** command. The Remote UNI ID field displays the name of the UNI as configured by the **ethernet uni id** command, or it displays the CFM MEP ID of the UNI when the UNI name has not been configured.

If the Remote UNI is missing from the table altogether, this is can be due to the following conditions:

- The remote UNI's EFP is missing from the bridge-domain in L2VPN configuration. Use the **show ethernet cfm configuration-errors** command to verify the configuration.
- A CFM MEP has not been configured on the remote UNI's EFP.

Configuring UDLD

UDLD is configured for each interface. The interface must be a physical ethernet interface.

Perform these steps to configure UDLD protocol on an interface.

SUMMARY STEPS

1. **configure**
2. **interface** [**GigabitEthernet | TenGigE**] *interface-path-id*
3. **ethernet udld**
4. **mode {normal |aggressive}**
5. **message-time** *[7-90]*
6. **logging disable**
7. **end**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface** [**GigabitEthernet | TenGigE**] *interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router(config)# interface
TenGigE 0/1/0/0
```

Enters interface configuration mode and specifies the Ethernet interface name and notation *rack/slot/module/port*.

Note
- The example indicates an 8-port 10-Gigabit Ethernet interface in modular services card slot 1.

Step 3 **ethernet udld**

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ethernet udld
```

Enables ethernet UDLD function and enters interface Ethernet UDLD configuration mode.

Step 4 **mode {normal |aggressive}**

Example:

```
RP/0/RSP0/CPU0:router(config-if-udld)# mode normal
```

(Optional) Specifies the mode of operation for UDLD. The options are normal and aggressive.

Step 5 **message-time** *[7-90]*

Example:

```
RP/0/RSP0/CPU0:router(config-if-udld)# message-time 70
```

(Optional) Specifies the message time (in seconds) to use for the UDLD protocol. The value ranges between 7 to 90 seconds.

Step 6 **logging disable**

Example:

```
RP/0/RSP0/CPU0:router(config-if-udld)# loggig disable
```

(Optional) This command suppresses the operational UDLD syslog messages.

Step 7 **end**

Example:

```
RP/0/RSP0/CPU0:router(config-if-udld)# end
```

Ends the configuration session and exits to the EXEC mode.

Configuration Examples for Ethernet OAM

This section provides the following configuration examples:

Configuration Examples for EOAM Interfaces

This section provides the following configuration examples:

Configuring an Ethernet OAM Profile Globally: Example

This example shows how to configure an Ethernet OAM profile globally:

```
configure terminal
 ethernet oam profile Profile_1
  link-monitor
   symbol-period window 60000
```

```
   symbol-period threshold low 10000000 high 60000000
   frame window 60
   frame threshold low 10000000 high 60000000
   frame-period window 60000
   frame-period threshold low 100 high 12000000
   frame-seconds window 900000
   frame-seconds threshold 3 threshold 900
   exit
  mib-retrieval
  connection timeout 30
  require-remote mode active
  require-remote link-monitoring
  require-remote mib-retrieval
  action dying-gasp error-disable-interface
  action critical-event error-disable-interface
  action discovery-timeout error-disable-interface
  action session-down error-disable-interface
  action capabilities-conflict error-disable-interface
  action wiring-conflict error-disable-interface
  action remote-loopback error-disable-interface
  commit
```

Configuring Ethernet OAM Features on an Individual Interface: Example

This example shows how to configure Ethernet OAM features on an individual interface:

```
configure terminal
 interface TenGigE 0/1/0/0
  ethernet oam
   link-monitor
    symbol-period window 60000
    symbol-period threshold low 10000000 high 60000000
    frame window 60
    frame threshold low 10000000 high 60000000
    frame-period window 60000
    frame-period threshold low 100 high 12000000
    frame-seconds window 900000
    frame-seconds threshold 3 threshold 900
    exit
   mib-retrieval
   connection timeout 30
   require-remote mode active
   require-remote link-monitoring
   require-remote mib-retrieval
   action link-fault  error-disable-interface
   action dying-gasp error-disable-interface
   action critical-event error-disable-interface
   action discovery-timeout error-disable-interface
   action session-down error-disable-interface
   action capabilities-conflict error-disable-interface
   action wiring-conflict error-disable-interface
   action remote-loopback error-disable-interface
   commit
```

Configuring Ethernet OAM Features to Override the Profile on an Individual Interface: Example

This example shows the configuration of Ethernet OAM features in a profile followed by an override of that configuration on an interface:

```
configure terminal
 ethernet oam profile Profile_1
```

```
  mode passive
  action dying-gasp disable
  action critical-event disable
  action discovery-timeout disable
  action session-up disable
  action session-down disable
  action capabilities-conflict disable
  action wiring-conflict disable
  action remote-loopback disable
  action uni-directional link-fault error-disable-interface
  commit

configure terminal
 interface TenGigE 0/1/0/0
  ethernet oam
   profile Profile_1
    mode active
    action dying-gasp log
    action critical-event log
    action discovery-timeout log
    action session-up log
    action session-down log
    action capabilities-conflict log
    action wiring-conflict log
    action remote-loopback log
    action uni-directional link-fault log
    uni-directional link-fault detection
    commit
```

Configuring a Remote Loopback on an Ethernet OAM Peer: Example

This example shows how to configure a remote loopback on an Ethernet OAM peer:

```
configure terminal
 interface gigabitethernet 0/1/5/6
  ethernet oam
   profile Profile_1
   remote-loopback
```

This example shows how to start a remote loopback on a configured Ethernet OAM interface:

```
ethernet oam loopback enable TenGigE 0/6/1/0
```

Clearing Ethernet OAM Statistics on an Interface: Example

This example shows how to clear Ethernet OAM statistics on an interface:

```
RP/0/RP0/CPU0:router# clear ethernet oam statistics interface gigabitethernet 0/1/5/1
```

Enabling SNMP Server Traps on a Router: Example

This example shows how to enable SNMP server traps on a router:

```
configure terminal
  ethernet oam profile Profile_1
  snmp-server traps ethernet oam events
```

Configuration Examples for Ethernet CFM

This section includes the following examples:

Ethernet CFM Domain Configuration: Example

This example shows how to configure a basic domain for Ethernet CFM:

```
configure
 ethernet cfm
  traceroute cache hold-time 1 size 3000
  domain Domain_One level 1 id string D1
  commit
```

Ethernet CFM Service Configuration: Example

This example shows how to create a service for an Ethernet CFM domain:

```
  service Bridge_Service bridge group BD1 bridge-domain B1
  service Cross_Connect_1 xconnect group XG1 p2p X1
  commit
```

Flexible Tagging for an Ethernet CFM Service Configuration: Example

This example shows how to set the number of tags in CFM packets from up MEPs in a CFM domain service:

```
configure
 ethernet cfm
  domain D1 level 1
   service S2 bridge group BG1 bridge-domain BD2
    tags 1
    commit
```

Continuity Check for an Ethernet CFM Service Configuration: Example

This example shows how to configure continuity-check options for an Ethernet CFM service:

```
   continuity-check archive hold-time 100
   continuity-check loss auto-traceroute
   continuity-check interval 100ms loss-threshold 10
   commit
```

MIP Creation for an Ethernet CFM Service Configuration: Example

This example shows how to enable MIP auto-creation for an Ethernet CFM service:

```
RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# mip auto-create all ccm-learning
RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# commit
```

Cross-check for an Ethernet CFM Service Configuration: Example

This example shows how to configure cross-check for MEPs in an Ethernet CFM service:

```
   mep crosscheck
    mep-id 10
```

```
    mep-id 20
    commit
```

Other Ethernet CFM Service Parameter Configuration: Example

This example shows how to configure other Ethernet CFM service options:

```
    maximum-meps 4000
    log continuity-check errors
    commit
    exit
   exit
  exit
```

MEP Configuration: Example

This example shows how to configure a MEP for Ethernet CFM on an interface:

```
interface gigabitethernet 0/1/0/1
 ethernet cfm
 mep domain Dm1 service Sv1 mep-id 1
 commit
```

Ethernet CFM Show Command: Examples

These examples show how to verify the configuration of Ethernet Connectivity Fault Management (CFM):

Example 1

This example shows how to display all the maintenance points that have been created on an interface:

```
RP/0/RSP0/CPU0:router# show ethernet cfm local maintenance-points

Domain/Level         Service              Interface         Type   ID   MAC
-------------------- -------------------- ----------------- ------ ---- --------
fig/5                bay                  Gi0/10/0/12.23456 Dn MEP    2 44:55:66
fig/5                bay                  Gi0/0/1/0.1       MIP         55:66:77
fred/3               barney               Gi0/1/0/0.1       Up MEP    5 66:77:88!
```

Example 2

This example shows how to display all the CFM configuration errors on all domains:

```
RP/0/RSP0/CPU0:router# show ethernet cfm configuration-errors

Domain fig (level 5), Service bay
* MIP creation configured using bridge-domain blort, but bridge-domain blort does not exist.

 * An Up MEP is configured for this domain on interface GigabitEthernet0/1/2/3.234 and an
Up MEP is also configured for domain blort, which is at the same level (5).
 * A MEP is configured on interface GigabitEthernet0/3/2/1.1 for this domain/service, which
 has CC interval 100ms, but the lowest interval supported on that interface is 1s
```

Example 3

This example shows how to display operational state for local maintenance end points (MEPs):

```
RP/0/RSP0/CPU0:router# show ethernet cfm local meps

 A - AIS received                I - Wrong interval
 R - Remote Defect received      V - Wrong Level
 L - Loop (our MAC received)     T - Timed out (archived)
 C - Config (our ID received)    M - Missing (cross-check)
 X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
 P - Peer port down

Domain foo (level 6), Service bar
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
  100 Gi1/1/0/1.234 (Up)       Up     0/0   N  A       L7

Domain fred (level 5), Service barney
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
    2 Gi0/1/0/0.234 (Up)       Up     3/2   Y  RPC     L6
Domain foo (level 6), Service bar
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
  100 Gi1/1/0/1.234 (Up)       Up     0/0   N  A

Domain fred (level 5), Service barney
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
    2 Gi0/1/0/0.234 (Up)       Up     3/2   Y  RPC
```

Example 4

This example shows how to display operational state of other maintenance end points (MEPs) detected by a local MEP:

```
RP/0/RSP0/CPU0:router# show ethernet cfm peer meps

Flags:
 > - Ok                          I - Wrong interval
 R - Remote Defect received      V - Wrong level
 L - Loop (our MAC received)     T - Timed out
 C - Config (our ID received)    M - Missing (cross-check)
 X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)

Domain fred (level 7), Service barney
Up MEP on GigabitEthernet0/1/0/0.234, MEP-ID 2
================================================================================
St    ID MAC address    Port    Up/Downtime   CcmRcvd SeqErr   RDI Error
-- ----- -------------- ------- ----------- --------- ------ ----- -----
 >     1 0011.2233.4455 Up      00:00:01         1234      0     0     0
R>     4 4455.6677.8899 Up      1d 03:04         3456      0   234     0
L      2 1122.3344.5566 Up      3w 1d 6h         3254      0     0  3254
C      2 7788.9900.1122 Test    00:13            2345      6    20  2345
X      3 2233.4455.6677 Up      00:23              30      0     0    30
I      3 3344.5566.7788 Down    00:34           12345      0   300  1234
V      3 8899.0011.2233 Blocked 00:35              45      0     0    45
 T     5 5566.7788.9900         00:56              20      0     0     0
M      6                                           0      0     0     0
U>     7 6677.8899.0011 Up      00:02             456      0     0     0

Domain fred (level 7), Service fig
Down MEP on GigabitEthernet0/10/0/12.123, MEP-ID 3
================================================================================
St    ID MAC address    Port    Up/Downtime  CcmRcvd SeqErr   RDI Error
```

```
-- ----- -------------- ------- ----------- -------- ------ ----- -----
 >     1 9900.1122.3344 Up      03:45           4321      0     0     0
```

Example 5

This example shows how to display operational state of other maintenance end points (MEPs) detected by a local MEP with details:

```
RP/0/RSP0/CPU0:router#  show ethernet cfm peer meps detail
Domain dom3 (level 5), Service ser3
Down MEP on GigabitEthernet0/0/0/0 MEP-ID 1
================================================================================
Peer MEP-ID 10, MAC 0001.0203.0403
   CFM state: Wrong level, for 00:01:34
   Port state: Up
   CCM defects detected:    V - Wrong Level
   CCMs received: 5
     Out-of-sequence:             0
     Remote Defect received:      5
     Wrong Level:                 0
     Cross-connect (wrong MAID):  0
     Wrong Interval:              5
     Loop (our MAC received):     0
     Config (our ID received):    0
Last CCM received 00:00:06 ago:
     Level: 4, Version: 0, Interval: 1min
     Sequence number: 5, MEP-ID: 10
     MAID: String: dom3, String: ser3
     Port status: Up, Interface status: Up


Domain dom4 (level 2), Service ser4
Down MEP on GigabitEthernet0/0/0/0 MEP-ID 1
================================================================================
Peer MEP-ID 20, MAC 0001.0203.0402
   CFM state: Ok, for 00:00:04
   Port state: Up
   CCMs received: 7
     Out-of-sequence:             1
     Remote Defect received:      0
     Wrong Level:                 0
     Cross-connect (wrong MAID):  0
     Wrong Interval:              0
     Loop (our MAC received):     0
  Config (our ID received):    0
Last CCM received 00:00:04 ago:
     Level: 2, Version: 0, Interval: 10s
     Sequence number: 1, MEP-ID: 20
     MAID: String: dom4, String: ser4
     Chassis ID: Local: ios; Management address: 'Not specified'
     Port status: Up, Interface status: Up

Peer MEP-ID 21, MAC 0001.0203.0403
   CFM state: Ok, for 00:00:05
   Port state: Up
   CCMs received: 6
     Out-of-sequence:             0
     Remote Defect received:      0
     Wrong Level:                 0
     Cross-connect (wrong MAID):  0
     Wrong Interval:              0
     Loop (our MAC received):     0
     Config (our ID received):    0
```

```
Last CCM received 00:00:05 ago:
     Level: 2, Version: 0, Interval: 10s
     Sequence number: 1, MEP-ID: 21
     MAID: String: dom4, String: ser4
     Port status: Up, Interface status: Up


Domain dom5 (level 2), Service ser5
Up MEP on Standby Bundle-Ether 1 MEP-ID 1
================================================================================
Peer MEP-ID 600, MAC 0001.0203.0401
   CFM state: Ok (Standby), for 00:00:08, RDI received
   Port state: Down
   CCM defects detected:    Defects below ignored on local standby MEP
                            I - Wrong Interval
                            R - Remote Defect received
   CCMs received: 5
     Out-of-sequence:             0
     Remote Defect received:    5
  Wrong Level:                 0
     Cross-connect W(wrong MAID): 0
     Wrong Interval:              5
     Loop (our MAC received):     0
     Config (our ID received):    0
   Last CCM received 00:00:08 ago:
     Level: 2, Version: 0, Interval: 10s
     Sequence number: 1, MEP-ID: 600
     MAID: DNS-like: dom5, String: ser5
     Chassis ID: Local: ios; Management address: 'Not specified'
     Port status: Up, Interface status: Down

Peer MEP-ID 601, MAC 0001.0203.0402
   CFM state: Timed Out (Standby), for 00:15:14, RDI received
   Port state: Down
   CCM defects detected:    Defects below ignored on local standby MEP
                            I - Wrong Interval
                            R - Remote Defect received
                            T - Timed Out
                            P - Peer port down
   CCMs received: 2
     Out-of-sequence:             0
     Remote Defect received:      2
     Wrong Level:                 0
     Cross-connect (wrong MAID):  0
     Wrong Interval:              2
     Loop (our MAC received):     0
     Config (our ID received):    0
   Last CCM received 00:15:49 ago:
     Level: 2, Version: 0, Interval: 10s
     Sequence number: 1, MEP-ID: 600
     MAID: DNS-like: dom5, String: ser5
     Chassis ID: Local: ios; Management address: 'Not specified'
     Port status: Up, Interface status: Down
```

AIS for CFM Configuration: Examples

Example 1

This example shows how to configure Alarm Indication Signal (AIS) transmission for a CFM domain service:

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# ethernet cfm
```

```
RP/0/RSP0/CPU0:router(config-cfm)# domain D1 level 1
RP/0/RSP0/CPU0:router(config-cfm-dmn)# service S1 bridge group BG1 bridge-domain BD2
RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# ais transmission interval 1m cos 7

configure
RP/0//CPU0:router(config)# ethernet cfm
RP/0//CPU0:router(config-cfm)# domain D1 level 1
RP/0//CPU0:router(config-cfm-dmn)# service Cross_Connect_1 xconnect group XG1 p2p
RP/0//CPU0:router(config-cfm-dmn-svc)# ais transmission interval 1m cos 7
```

Example 2

This example shows how to configure AIS logging for a Connectivity Fault Management (CFM) domain service to indicate when AIS or LCK packets are received:

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# ethernet cfm
RP/0/RSP0/CPU0:router(config-cfm)# domain D1 level 1
RP/0/RSP0/CPU0:router(config-cfm-dmn)# service S2 bridge group BG1 bridge-domain BD2
RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# log ais

configure
RP/0//CPU0:router(config)# ethernet cfm
RP/0//CPU0:router(config-cfm)# domain D1 level 1
RP/0//CPU0:router(config-cfm-dmn)# service Cross_Connect_1 xconnect group XG1 p2p
RP/0//CPU0:router(config-cfm-dmn-svc)# log ais
```

This example shows how to configure AIS transmission on a CFM interface.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface gigabitethernet 0/1/0/2
RP/0/RSP0/CPU0:router(config-if)# ethernet cfm
RP/0/0RP0RSP0/CPU0:router(config-if-cfm)# ais transmission up interval 1m cos 7
```

AIS for CFM Show Commands: Examples

This section includes the following examples:

show ethernet cfm interfaces ais Command: Example

This example shows how to display the information published in the Interface AIS table:

```
RP/0/RSP0/CPU0:router# show ethernet cfm interfaces ais

Defects (from at least one peer MEP):
 A - AIS received                I - Wrong interval
 R - Remote Defect received      V - Wrong Level
 L - Loop (our MAC received)     T - Timed out (archived)
 C - Config (our ID received)    M - Missing (cross-check)
 X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
 P - Peer port down              D - Local port down

                           Trigger                  Transmission
                     AIS   ---------    Via    ----------------------------
Interface (State)    Dir   L Defects  Levels   L Int Last started  Packets
-------------------- ---   - -------  -------  - --- ------------ ---------
Gi0/1/0/0.234 (Up)   Dn    5 RPC      6        7 1s  01:32:56 ago     5576
Gi0/1/0/0.567 (Up)   Up    0 M        2,3      5 1s  00:16:23 ago      983
```

```
Gi0/1/0/1.1 (Dn)         Up     D                7 60s 01:02:44 ago     3764
Gi0/1/0/2 (Up)           Dn   0 RX       1!
```

show ethernet cfm local meps Command: Examples

Example 1: Default

The following example shows how to display statistics for local maintenance end points (MEPs):

```
RP/0/RSP0/CPU0:router# show ethernet cfm local meps

 A - AIS received                I - Wrong interval
 R - Remote Defect received      V - Wrong Level
 L - Loop (our MAC received)     T - Timed out (archived)
 C - Config (our ID received)    M - Missing (cross-check)
 X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
 P - Peer port down

Domain foo (level 6), Service bar
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
  100 Gi1/1/0/1.234 (Up)       Up     0/0   N  A       7

Domain fred (level 5), Service barney
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
    2 Gi0/1/0/0.234 (Up)       Up     3/2   Y  RPC     6
```

Example 2: Domain Service

The following example shows how to display statistics for MEPs in a domain service:

```
RP/0/RSP0RP0/CPU0:router# show ethernet cfm local meps domain foo service bar detail

Domain foo (level 6), Service bar
Up MEP on GigabitEthernet0/1/0/0.234, MEP-ID 100
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 0 up, 0 with errors, 0 timed out (archived)

  CCM generation enabled:  No
  AIS generation enabled:  Yes (level: 7, interval: 1s)
  Sending AIS:             Yes (started 01:32:56 ago)
  Receiving AIS:           Yes (from lower MEP, started 01:32:56 ago)

Domain fred (level 5), Service barney
Up MEP on GigabitEthernet0/1/0/0.234, MEP-ID 2
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 3 up, 2 with errors, 0 timed out (archived)
  Cross-check defects: 0 missing, 0 unexpected

  CCM generation enabled:  Yes (Remote Defect detected: Yes)
  CCM defects detected:    R - Remote Defect received
                           P - Peer port down
                           C - Config (our ID received)
  AIS generation enabled:  Yes (level: 6, interval: 1s)
  Sending AIS:             Yes (to higher MEP, started 01:32:56 ago)
  Receiving AIS:           No
```

Example 3: Verbose

The following example shows how to display verbose statistics for MEPs in a domain service:

Note The Discarded CCMs field is not displayed when the number is zero (0). It is unusual for the count of discarded CCMs to be any thing other than zero, since CCMs are only discarded when the limit on the number of peer MEPs is reached.

```
RP/0/RSP0RP0/CPU0:router# show ethernet cfm local meps domain foo service bar verbose

Domain foo (level 6), Service bar
Up MEP on GigabitEthernet0/1/0/0.234, MEP-ID 100
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 0 up, 0 with errors, 0 timed out (archived)

  CCM generation enabled:  No
  AIS generation enabled:  Yes (level: 7, interval: 1s)
  Sending AIS:             Yes (started 01:32:56 ago)
  Receiving AIS:           Yes (from lower MEP, started 01:32:56 ago)

  Packet        Sent      Received
  ------  ----------  ----------------------------------------------------
  CCM             20            20  (out of seq: 0)
  AIS           5576            0

Domain fred (level 5), Service barney
Up MEP on GigabitEthernet0/1/0/0.234, MEP-ID 2
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 3 up, 2 with errors, 0 timed out (archived)
  Cross-check defects: 0 missing, 0 unexpected

  CCM generation enabled:  Yes (Remote Defect detected: Yes)
  CCM defects detected:    R - Remote Defect received
                           P - Peer port down
                           C - Config (our ID received)
  AIS generation enabled:  Yes (level: 6, interval: 1s)
  Sending AIS:             Yes (to higher MEP, started 01:32:56 ago)
  Receiving AIS:           No

  Packet        Sent      Received
  ------  ----------  ------------------------------------------------------------
  CCM          12345         67890  (out of seq: 6, discarded: 10)
  LBM              5             0
  LBR              0             5  (out of seq: 0, with bad data: 0)
  AIS              0         46910
  LCK              -             0
```

Example 4: Detail

The following example shows how to display detailed statistics for MEPs in a domain service:

```
RP/0/RSP0/CPU0:router# show ethernet cfm local meps detail

Domain foo (level 6), Service bar
Up MEP on GigabitEthernet0/1/0/0.234, MEP-ID 100
================================================================================
```

```
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 0 up, 0 with errors, 0 timed out (archived)

  CCM generation enabled:  No
  AIS generation enabled:  Yes (level: 7, interval: 1s)
  Sending AIS:             Yes (started 01:32:56 ago)
  Receiving AIS:           Yes (from lower MEP, started 01:32:56 ago)

Domain fred (level 5), Service barney
Up MEP on GigabitEthernet0/1/0/0.234, MEP-ID 2
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 3 up, 2 with errors, 0 timed out (archived)
  Cross-check defects: 0 missing, 0 unexpected

  CCM generation enabled:  Yes (Remote Defect detected: Yes)
  CCM defects detected:    R - Remote Defect received
                           P - Peer port down
                           C - Config (our ID received)
  AIS generation enabled:  Yes (level: 6, interval: 1s)
  Sending AIS:             Yes (to higher MEP, started 01:32:56 ago)
  Receiving AIS:           No
```

EFD Configuration: Examples

This example shows how to enable EFD:

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# ethernet cfm
RP/0/RSP0/CPU0:router(config-cfm)# domain D1 level 1
RP/0/RSP0/CPU0:router(config-cfm-dmn)# service S1 down-meps
RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# efd
```

This example shows how to enable EFD logging:

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# ethernet cfm
RP/0/RSP0/CPU0:router(config-cfm)# domain D1 level 1
RP/0/RSP0/CPU0:router(config-cfm-dmn)# service S1 down-meps
RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# log efd
```

Displaying EFD Information: Examples

The following examples show how to display information about EFD:

show efd interfaces Command: Example

This example shows how to display all interfaces that are shut down in response to an EFD action:

```
RP/0/RSP0/CPU0:router# show efd interfaces

Server VLAN MA
==============
Interface         Clients
-------------------------
GigE0/0/0/0.0     CFM
```

show ethernet cfm local meps detail Command: Example

Use the **show ethernet cfm local meps detail** command to display MEP-related EFD status information. The following example shows that EFD is triggered for MEP-ID 100:

```
RP/0/RSP0/CPU0:router# show ethernet cfm local meps detail

Domain foo (level 6), Service bar
Up MEP on GigabitEthernet0/1/0/0.234, MEP-ID 100
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 0 up, 0 with errors, 0 timed out (archived)
  Cross-check errors: 2 missing, 0 unexpected

  CCM generation enabled:  No
  AIS generation enabled:  Yes (level: 7, interval: 1s)
  Sending AIS:             Yes (started 01:32:56 ago)
  Receiving AIS:           Yes (from lower MEP, started 01:32:56 ago)
  EFD triggered:           Yes

Domain fred (level 5), Service barney
Up MEP on GigabitEthernet0/1/0/0.234, MEP-ID 2
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 3 up, 0 with errors, 0 timed out (archived)
  Cross-check errors: 0 missing, 0 unexpected

  CCM generation enabled:  Yes (Remote Defect detected: No)
  AIS generation enabled:  Yes (level: 6, interval: 1s)
  Sending AIS:             No
  Receiving AIS:           No
  EFD triggered:           No
```

Note You can also verify that EFD has been triggered on an interface using the **show interfaces** and **show interfaces brief** commands. When an EFD trigger has occurred, these commands will show the interface status as *up* and the line protocol state as *down*.

Configuration Examples for Ethernet SLA

This section includes the following examples:

Ethernet SLA Profile Type Configuration: Examples

These examples show how to configure the different profile types supported by Ethernet SLA.

Example 1

This example configures a profile named “Prof1” for CFM loopback measurements:

```
configure
 ethernet sla
  profile  Prof1 type cfm-loopback
   commit
```

Example 2

This example configures a profile named “Prof1” for CFM delay measurements. Setting this type allows you to configure the probe to measure additional one-way delay and jitter statistics:

```
configure
 ethernet sla
  profile  Prof1 type cfm-delay-measurement
   commit
```

Ethernet SLA Probe Configuration: Examples

These examples show how to configure some of the packet options for an Ethernet CFM loopback probe.

Example 1

This example shows how to configure sending a group of 100 packets in 100 ms intervals and repeat that burst every 60 seconds. Packets are padded to a size of 9000 bytes as needed using a hexadecimal test pattern of “abcdabcd,” and with a class of service value of 7:

Note The total length of a burst (packet count multiplied by the interval) must not exceed 1 minute.

```
configure
 ethernet sla
  profile  Prof1 type cfm-loopback
   probe
    send burst every 60 seconds packet count 100 interval 100 milliseconds
    packet size 9000 test pattern hex 0xabcdabcd
    priority 7
    commit
```

Example 2

This example has the same characteristics as the configuration in Example 1, but sends a single burst of 50 packets, one second apart:

```
configure
 ethernet sla
  profile  Prof1 type cfm-loopback
   probe
    send burst once packet count 50 interval 1 second
    packet size 9000 test pattern hex 0xabcdabcd
    priority 7
    commit
```

Example 3

This example shows how to configure a continuous stream of packets at 100 ms intervals for the duration of the probe. Packets are padded to a size of 9000 bytes as needed using a pseudo-random test pattern, and with a class of service value of 7:

```
configure
 ethernet sla
  profile Prof1 type cfm-loopback
```

```
 probe
  send burst every 60 seconds packet count 600 interval 100 milliseconds
  packet size 9000 test pattern pseudo-random
  priority 7
  commit
```

Profile Statistics Measurement Configuration: Examples

These examples show how to configure the different types of statistics measurement.

Example 1

This example shows the two available types of statistics that can be measured by a CFM loopback SLA profile type:

```
configure
 ethernet sla
  profile  Prof1 type cfm-loopback
  statistics measure round-trip-delay
  statistics measure round-trip-jitter
   commit
```

Example 2

This example shows how to configure measurement of round-trip delay and one-way jitter (from destination to source) for a CFM delay measurement SLA profile type:

Note The CFM delay measurement profile type supports measurement of all round-trip and one-way delay and jitter statistics.

```
configure
 ethernet sla
  profile  Prof1 type cfm-delay-measurement
  statistics measure round-trip-delay
  statistics measure one-way-jitter-ds
   commit
```

Scheduled SLA Operation Probe Configuration: Examples

These examples show how to configure different schedules for an SLA operation probe.

Example 1

This example shows how to configure a probe to run hourly for a specified duration:

```
configure
 ethernet sla
  profile  Prof1 type cfm-delay-measurement
  schedule every 1 hours for 15 minutes
  commit
```

Example 2

This example shows how to configure a probe to run daily for a specified period of time:

```
configure
 ethernet sla
  profile  Prof1 type cfm-delay-measurement
  schedule every day at 11:30 for 5 minutes
  commit
```

Example 3

This example shows how to configure a probe to run weekly beginning at a specified time and for a specified duration:

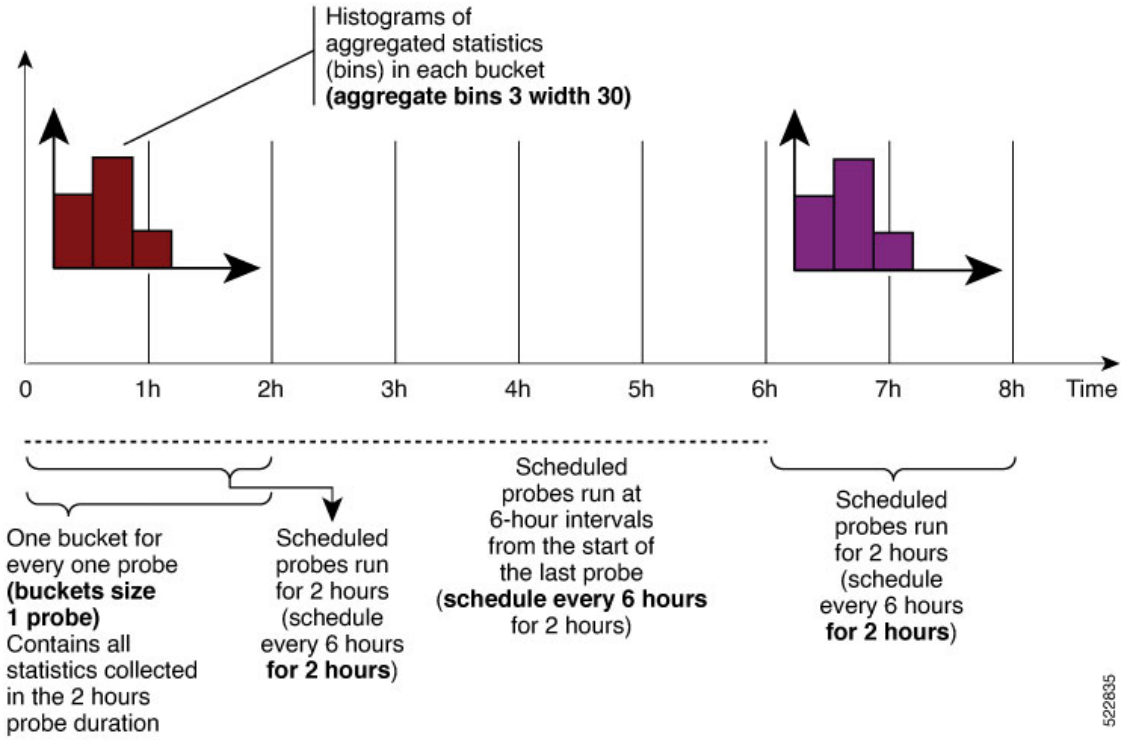
```
configure
 ethernet sla
  profile  Prof1 type cfm-delay-measurement
  schedule every week on Monday at 23:30 for 1 hour
  commit
```

Ethernet SLA Operation Probe Scheduling and Aggregation Configuration: Example

This figure shows a more comprehensive example of how some of the probe scheduling and measurement configuration works using aggregation. The following configuration supports some of the concepts shown in the figure:

```
configure
 ethernet sla profile Prof1 type cfm-loopback
  probe
   send packet every 60 seconds
   schedule every 6 hours for 2 hours
   statistics measure round-trip-delay
    aggregate bins 3 width 30
    buckets size 1 probes
    buckets archive 4
    commit
```

Figure 13: SLA Probe Scheduling Operation With Bin Aggregation



This example schedules a probe with the following characteristics:

- Sends packets 60 seconds apart (for a 2-hour probe, this results in sending 120 individual packets).
- Probe runs every 6 hours for 2 hours duration.
- Collects data into 1 bucket for every probe, so each bucket covers 2 hours of the 2-hour probe duration.
- Aggregates statistics within the buckets into 3 bins each in the following ranges:
  - Bin 1 contains samples in the range 0 to < 30 ms.
  - Bin 2 contains samples in the range 30 ms to < 60 ms.
  - Bin 3 contains samples in the range 60 ms or greater (unbounded).
- The last 4 buckets are saved in memory.

Ongoing Ethernet SLA Operation Configuration: Example

This example shows how to configure an ongoing Ethernet SLA operation on a MEP:

```
interface gigabitethernet 0/1/0/1
 ethernet cfm
 mep domain Dm1 service Sv1 mep-id 1
 sla operation profile Profile_1 target mac-address 01:23:45:67:89:ab s
 commit
 end
```

On-Demand Ethernet SLA Operation Basic Configuration: Examples

These examples show how to configure on-demand Ethernet SLA operations.

Example 1

This example shows how to configure a basic on-demand Ethernet SLA operation for a CFM loopback probe that by default will measure round-trip delay and round-trip jitter for a one-time, 10-second operation to the target MEP:

```
RP/0//CPU0:router# ethernet sla on-demand operation type cfm-loopback probe domain D1 source
 interface TenGigE 0/6/1/0 target mep-id 1
```

Example 2

This example shows how to configure a basic on-demand Ethernet SLA operation for a CFM delay measurement probe that by default will measure one-way delay and jitter in both directions, as well as round-trip delay and round-trip jitter for a one-time, 10-second operation to the target MEP:

```
RP/0//CPU0:router# ethernet sla on-demand operation type cfm-delay-measurement probe domain
 D1 source interface TenGigE 0/6/1/0 target mep-id 1
```

Ethernet SLA Y.1731 SLM Configuration: Examples

These examples show how to configure the synthetic loss measurement statistics.

Example 1

This example shows the default configuration for Y.1731 SLM:

```
ethernet sla
  profile sl1 type cfm-synthetic-loss-measurement
    statistic measure one-way-loss-sd
    statistic measure one-way-loss-ds
```

Example 2

This example configures a profile named “Sl2” for synthetic loss measurements. with the parameters to configure the probe and SLM statistics:

```
ethernet sla
  profile sl2 type cfm-synthetic-loss-measurement
    probe
      send burst every 5 seconds packet count
                    100 interval 50 milliseconds
      packet size 400 test pattern hex 0xABDC1234
      synthetic loss calculation packets 200
    schedule every 1 hours for 1 minute
    statistic measure one-way-loss-sd
    statistic measure one-way-loss-ds
      aggregate bins 3 width 30
      bucket size 24 probes
```

Ethernet SLA Show Commands: Examples

These examples show how to display information about configured SLA operations:

show ethernet sla operations Command: Example 1

```
RP/0/RSP0/CPU0:router# show ethernet sla operations interface gigabitethernet 0/1/0/1.1

Interface GigabitEthernet0/1/0/1.1
Domain mydom Service myser to 00AB.CDEF.1234
--------------------------------------------------------------------------------
Profile 'business-gold'
Probe type CFM-delay-measurement:
    bursts sent every 1min, each of 20 packets sent every 100ms
    packets padded to 1500 bytes with zeroes
    packets use priority value of 7
Measures RTT: 5 bins 20ms wide; 2 buckets/ probe; 75/100 archived
Measures Jitter (interval 1): 3 bins 40ms wide; 2 buckets/probe; 50 archived
Scheduled to run every Sunday at 4am for 2 hours:
    last run at 04:00 25/05/2008
```

show ethernet sla configuration-errors Command: Example 2

```
RP/0/RSP0/CPU0:router# show ethernet sla configuration-errors

Errors:
-------
  Profile 'gold' is not defined but is used on Gi0/0/0/0.0
  Profile 'red' defines a test-pattern, which is not supported by the type
```

These examples show how to display the contents of buckets containing SLA metrics collected by probes:

show ethernet sla statistics current Command: Example 3

```
RP/0/RSP0/CPU0:router# show ethernet sla statistics current interface GigabitEthernet
0/0/0/0.0

Interface GigabitEthernet 0/0/0/0.0
Domain mydom Service myser to 00AB.CDEF.1234
================================================================================
Profile 'business-gold', packet type 'cfm-loopback'
Scheduled to run every Sunday at 4am for 2 hours

Round Trip Delay
~~~~~~~~~~~~~~~~
2 buckets per probe

Bucket started at 04:00 Sun 17 Feb 2008 lasting 1 hour:
    Pkts sent: 2342; Lost 2 (0%); Corrupt: 0 (0%); Misordered: 0 (0%)
    Min: 13ms; Max: 154ms; Mean: 28ms; StdDev: 11ms

Round Trip Jitter
~~~~~~~~~~~~~~~~~
2 buckets per probe

Bucket started at 04:00 Sun 17 Feb 2008 lasting 1 hour:
    Pkts sent: 2342; Lost: 2 (0%); Corrupt: 0 (0%); Misordered: 0 (0%)
    Min: -5ms; Max: 8ms; Mean: 0ms; StdDev: 3.6ms
```

```
Bucket started at 05:00 Sun 17 Feb 2008 lasting 1 hour:
    Pkts sent: 2342; Lost: 2 (0%); Corrupt: 0 (0%); Misordered: 0 (0%)
    Min: 0; Max: 4; Mean: 1.4; StdDev: 1
```

show ethernet sla statistics history detail Command: Example 4

```
RP/0/RSP0/CPU0:router# show ethernet sla history detail GigabitEthernet 0/0/0/0.0

Interface GigabitEthernet 0/0/0/0.0
Domain mydom Service myser to 00AB.CDEF.1234
================================================================================
Profile 'business-gold', packet type 'cfm-loopback'
Scheduled to run every Sunday at 4am for 2 hours

Round Trip Delay
~~~~~~~~~~~~~~~~
2 buckets per probe

Bucket started at 04:00 Sun 17 Feb 2008 lasting 1 hour:
    Pkts sent: 2342; Lost: 2 (0%); Corrupt: 0 (0%); Misordered: 0 (0%)
    Min: 13ms, occurred at 04:43:29 on Sun 22 Aug 2010 UTC
    Max: 154ms, occurred at 05:10:32 on Sun 22 Aug 2010 UTC
    Mean: 28ms; StdDev: 11ms

    Results suspect as more than 10 seconds time drift detected
    Results suspect as scheduling latency prevented some packets being sent

    Samples:
    Time sent       Result  Notes
    ------------  --------  ----------
    04:00:01.324      23ms
    04:00:01.425      36ms
    04:00:01.525         -  Timed Out
    ...

Round Trip Jitter
~~~~~~~~~~~~~~~~~
2 buckets per probe

Bucket started at 04:00 Sun 17 Feb 2008, lasting 1 hour:
    Pkts sent: 2342; Lost: 2 (0%); Corrupt: 0 (0%); Misordered: 0 (0%)
    Min: -5ms; Max: 10ms; Mean: 0ms; StdDev: 3.6ms

    Samples:
    Time sent       Result  Notes
    ------------  --------  ----------
    04:00:01.324         -
    04:00:01.425      13ms
    04:00:01.525         -  Timed out
    ...
```

show ethernet sla statistics history detail on-demand: Example 5

This example shows how to display statistics for all full buckets for on-demand operations in detail:

```
RP/0//CPU0/router #show ethernet sla statistics history detail on-demand

Interface GigabitEthernet0/0/0/0.1
Domain mydom Service myser to 0123.4567.890A
================================================================================
On-demand operation ID #1, packet type 'cfm-delay-measurement'
```

```
Started at 15:38 on 06 July 2010 UTC, runs every 1 hour for 1 hour

Round Trip Delay
~~~~~~~~~~~~~~~~
1 bucket per probe

Bucket started at 15:38 on Tue 06 Jul 2010 UTC, lasting 1 hour:
    Pkts sent: 1200; Lost: 4 (0%); Corrupt: 600 (50%); Misordered: 0 (0%)
    Min: 13ms, occurred at 15:43:29 on Tue 06 Jul 2010 UTC
    Max: 154ms, occurred at 16:15:34 on Tue 06 Jul 2010 UTC
    Mean: 28ms; StdDev: 11ms

    Bins:
    Range              Samples    Cum. Count      Mean
    ------------  ------------  ------------  --------
     0 - 20 ms       194 (16%)     194 (16%)      17ms
    20 - 40 ms       735 (61%)     929 (77%)      27ms
    40 - 60 ms       212 (18%)    1141 (95%)      45ms
    > 60    ms        55  (5%)    1196            70ms

Bucket started at 16:38 on Tue 01 Jul 2008 UTC, lasting 1 hour:
    Pkts sent: 3600; Lost: 12 (0%); Corrupt: 1800 (50%); Misordered: 0 (0%)
    Min: 19ms, occurred at 17:04:08 on Tue 06 Jul 2010 UTC
    Max: 70ms, occurred at 16:38:00 on Tue 06 Jul 2010 UTC
    Mean: 28ms; StdDev: 11ms

    Bins:
    Range              Samples    Cum. Count      Mean
    ------------  ------------  ------------  --------
     0 - 20 ms       194 (16%)     194 (16%)      19ms
    20 - 40 ms       735 (61%)     929 (77%)      27ms
    40 - 60 ms       212 (18%)    1141 (95%)      45ms
    > 60    ms        55  (5%)    1196            64ms
```

show ethernet sla statistics profile Command: Example 6

These examples show how to display statistics for synthetic loss measurement in detail:

```
RP/0/RSP0/CPU0:router#show ethernet sla statistics profile sl2 statistic one-way-loss-sd
detail

Source: Interface GigabitEthernet0/0/0/0, Domain dom1
Destination: Target MAC Address 0002.0003.0005
================================================================================
Profile 'sl1', packet type 'cfm-synthetic-loss-measurement'
Scheduled to run every 1hr first at 00:50:00 UTC for 1min
Frame Loss Ratio calculated every 10s

One-way Frame Loss (Source->Dest)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 04:50:00 PDT Thu 15 September 2012 lasting 1hr
    Pkts sent: 1200; Lost: 27 (2.25%); Corrupt: 0 (0.0%);
                  Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Min: 0.00%, occurred at 04:50:50 PDT Thu 15 September 2011
    Max: 5.50%, occurred at 04:50:20 PDT Thu 15 September 2011
    Mean: 2.08%; StdDev: 1.99%; Overall: 2.08%

    Measurements:
    Time                     Result  Notes
    ----------  -------------------  ----------
    04:50:00.0    1.50% (3 of 200)
    04:50:10.0    2.00% (4 of 200)
```

```
    04:50:20.0    5.50% (11 of 200)
    04:50:30.0    3.00% (6 of 200)
    04:50:40.0    0.50% (1 of 200)
    04:50:50.0    0.00% (0 of 200)
```

In the example 6, the description of the statistics that indicate the lost count and overall FLR are Lost: 27 (2.25%) and Overall: 2.08%. The lost count means that 27 SLMs were lost out of 1200, but it might not be possible to determine in which direction they were lost. The overall FLR reports the overall loss in the Source to Destination direction.

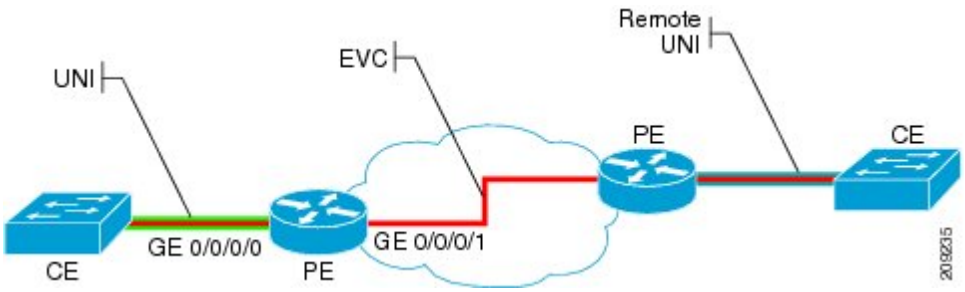
show ethernet sla statistics profile Command: Example 7

```
RP/0/RSP0/CPU0:ios#show ethernet sla statistics profile sl2 statistic one-way-loss-ds detail
Source: Interface GigabitEthernet0/0/0/0, Domain dom1
Destination: Target MAC Address 0002.0003.0005
================================================================================
Profile 'sl2', packet type 'cfm-synthetic-loss-measurement'
Scheduled to run every 1hr first at 00:55:00 UTC for 1min
Frame Loss Ratio calculated every 10s

One-way Frame Loss (Dest->Source)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
24 probes per bucket

Bucket started at 04:55:00 PDT Thu 15 September 2012 lasting 1 day
    Pkts sent: 28800; Lost: 14691 (51.01%); Corrupt: 0 (0.0%);
                      Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Min: 10.00%, occurred at 04:55:00 PDT Thu 15 September 2011
    Max: 68.80%, occurred at 06:55:00 PDT Thu 15 September 2011
    Mean: 52.5%; StdDev: 0.00%; Overall: 51.00%

    Bins:
    Range             Count  Cum. Count    Mean
    -----------  ----------  ----------  ------
      0 to  30%  20 (13.9%)  20 (13.9%)  21.00%
     30 to  60%  71 (49.3%)  91 (63.2%)  57.90%
     60 to 100%  49 (34.0%) 144 (100.0%) 62.00%
```

Configuration Example for Ethernet LMI

Figure 16 shows a basic E-LMI network environment with a local UNI defined on a Cisco ASR 9000 Series Router functioning as the PE using Gigabit Ethernet interface 0/0/0/0, and connectivity to a remote UNI over Gigabit Ethernet interface 0/0/0/1.

Figure 14: Basic E-LMI UNI and Remote UNI Diagram



The following configuration provides a basic E-LMI configuration for the environment shown in Figure 16, for the Cisco ASR 9000 Series Router as the PE device on the local UNI with physical Gigabit Ethernet interfaces 0/0/0/0 and 0/0/0/1:

```
RP/0/RSP0/CPU0:router# configure
!
! Configure the Local UNI EFPs
!
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet0/0/0/0.0 l2transport
RP/0/RSP0/CPU0:router(config-subif)# #encapsulation dot1q 1-20
RP/0/RSP0/CPU0:router(config-subif)# exit
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet0/0/0/1.1 l2transport
RP/0/RSP0/CPU0:router(config-subif)# #encapsulation dot1q 1-20
RP/0/RSP0/CPU0:router(config-subif)# exit
!
! Create the EVC
!
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group BG1
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain BD1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# interface GigabitEthernet0/0/0/0.0
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# interface GigabitEthernet0/0/0/1.1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# exit
RP/0/RSP0/CPU0:router(config-l2vpn)# exit
!
! Configure Ethernet CFM
!
RP/0/RSP0/CPU0:router(config)# ethernet cfm
RP/0/RSP0/CPU0:router(config-cfm)# domain GLOBAL level 5
RP/0/RSP0/CPU0:router(config-cfm-dmn)# service CustomerA bridge group BG1 bridge-domain BD1
RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# continuity-check interval 100ms
RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# mep crosscheck mep-id 22
RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# mep crosscheck mep-id 11
RP/0/RSP0/CPU0:router(config-cfm-dmn-svc)# exit
RP/0/RSP0/CPU0:router(config-cfm-dmn)# exit
RP/0/RSP0/CPU0:router(config-cfm)# exit
!
! Configure EFPs as CFM MEPs
!
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet0/0/0/0.0 l2transport
RP/0/RSP0/CPU0:router(config-subif)# ethernet cfm
RP/0/RSP0/CPU0:router(config-if-cfm)# mep domain GLOBAL service CustomerA mep-id 22
RP/0/RSP0/CPU0:router(config-if-cfm)# exit
RP/0/RSP0/CPU0:router(config-subif)# exit
!
! Configure the Local UNI Name
!
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/0/0/0
RP/0/RSP0/CPU0:router(config-if)# ethernet uni id PE1-CustA-Slot0-Port0
RP/0/RSP0/CPU0:router(config-if)# exit
!
! Enable E-LMI on the Local UNI Physical Interface
!
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/0/0/0
RP/0/RSP0/CPU0:router(config-if)# ethernet lmi
RP/0/RSP0/CPU0:router(config-if)# exit
RP/0/RSP0/CPU0:router(config)# commit
```

Configuration Examples for Ethernet Data Plane Loopback

This example shows how to configure Ethernet Data Plane Loopback:

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/1/0/1
RP/0/RSP0/CPU0:router(config-if-srv)# ethernet loopback permit external
```

This example shows how to start an Ethernet Data Plane Loopback:

```
RP/0/RSP0/CPU0:router# ethernet loopback start local interface gigabitEthernet
 0/1/0/1
external

[source mac-address <addr>]
 [destination mac-address <addr>]
 [ether-type <etype>]
 [{dot1q <vlan-ids> [second-dot1q <vlan-ids>] |
  dot1ad <vlan-ids> [dot1q <vlan-ids>]}]
 [cos <cos>]
 [llc-oui <oui>]
 [timeout {<length> | none}]
```

This example shows how to stop an Ethernet Data Plane Loopback session:

```
RP/0/RSP0/CPU0:router# ethernet loopback stop local interface <name> id <id>
```

This example shows how to extend an Ethernet Data Plane Loopback session:

```
RP/0/RSP0/CPU0:router# ethernet loopback extend local interface <name> id <id>
 length
<length>
```

Verification

- Use the **show ethernet loopback permitted** command to display all the permitted interfaces which run Ethernet Data Plane Loopback sessions:

```
RP/0/RSP0/CPU0:router# show ethernet loopback permitted
Interface Direction
-----------------------------------------------
GigabitEthernet0/0/0/0 External
GigabitEthernet0/0/0/1.100 Internal
TenGigE0/1/0/0.200 External, Internal
```

- Use the **show ethernet loopback active** command to view active sessions:

```
RP/0/RSP0/CPU0:router# show ethernet loopback active interface
TenGigE0/1/0/0.200

Local: TenGigE0/1/0/0.200, ID 1
=============================================
Direction: Internal
Time out: 2 hours
Time left: 00:01:17
Status: Active
Filters:
```

```
 Dot1ad: 100-200
 Dot1q: Any
 Source MAC Address: aaaa.bbbb.cccc
 Destination MAC Address: Any
 Ethertype: 0x8902
 Class of Service: Any
 LLC-OUI: Any
Local: TenGigE0/1/0/0.200, ID 2
================================================
Direction: External
Time out: 10 minutes
Time left: 00:00:00
Status: Stopping
Filters:
 Dot1q: 500
 Second-dot1q: 200
 Source MAC Address: Any
 Destination MAC Address: Any
 Ethertype: Any
 Class of Service: 4
 LLC-OUI: Any
```

For each loopback session listed, this information is displayed:

- Header containing the Interface name and session ID, which uniquely identify the local loopback session,
- Direction which specifies the direction of the loopback,
- Time out – the time out period specified when the loopback was started,
- Time left – the amount of time left until the loopback session is automatically stopped,
- Status – the status of the loopback session,
- Filters – details of the filters specified when the loopback session was started. Similar to the start CLI, only the filters supported by the platform are displayed.

Where to Go Next

When you have configured an Ethernet interface, you can configure individual VLAN subinterfaces on that Ethernet interface.

For information about modifying Ethernet management interfaces for the shelf controller (SC), route processor (RP), and distributed RP, see the “Advanced Configuration and Modification of the Management Ethernet Interface on the Cisco ASR 9000 Series Router” module later in this document.

For information about IPv6 see the Implementing Access Lists and Prefix Lists on

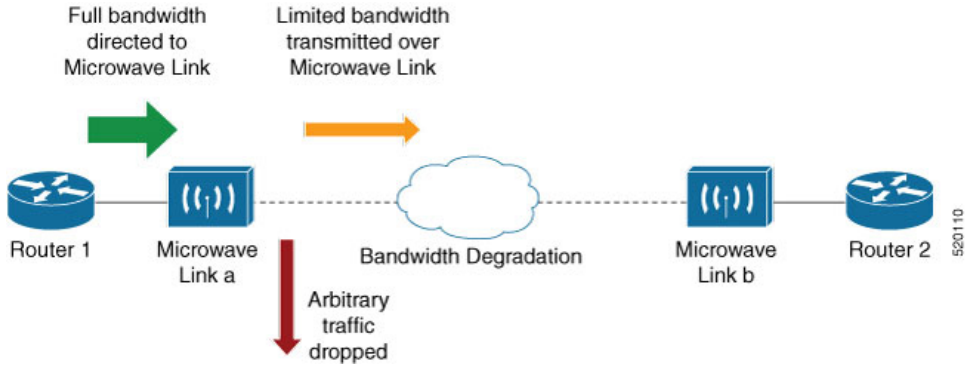
Cisco IOS XR Software module in the Cisco IOS XR IP Addresses and Services Configuration Guide

CFM Adaptive Bandwidth Notifications

Microwave links are used in carrier ethernet networks, because they are less expensive than laying fibre in dense metro areas and rural locations. However, the disadvantage of microwave links is that the signal is affected by atmospheric conditions and can degrade.

Modern microwave devices support adaptive modulation schemes to prevent complete loss of signal. This allows them to continue to operate during periods of degradation, but at a reduced bandwidth. However, to

fully take advantage of this scheme, it's necessary to convey the decrease in bandwidth to the head-end router so that appropriate actions can be taken. Otherwise, the link may become saturated and traffic dropped arbitrarily as shown in the following figure:



A generic solution to this traffic drop issue is Connectivity Fault Management (CFM) extension to send Bandwidth Notifications Messages (BNM) to Maintenance Endpoints (MEPs) on the corresponding interface at the head-end router. To be flexible in the actions that are to be taken, the solution uses Embedded Event Manager (EEM) to invoke operator written TCL scripts. For information on EEM, see Embedded Event Manager, on page 140.

Note This feature is supported only on 64-bit Linux-based IOS XR ASR 9000 operating system.

Bandwidth Notification Messages

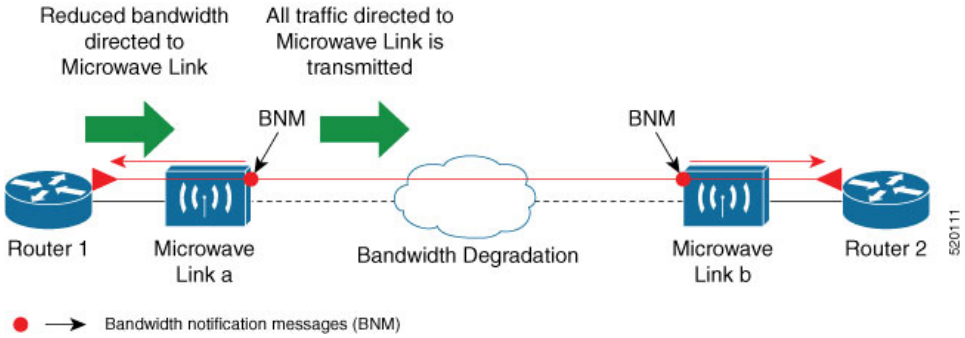
The two types of messages used to notify the head-end router are:

- G.8013 Bandwidth Notification Messages (G.8013 BNM)
- Cisco proprietary Bandwidth Vendor-Specific Messages (Cisco BW-VSM)

Both message types contain the following information:

- Source MAC
- Port ID
- Maintenance Domain (MD) Level
- Transmission period
- Nominal Bandwidth
- Current Bandwidth

During signal degradation, periodic BNMs are sent to the head-end router containing the current bandwidth (sampled over a period of time) and nominal bandwidth (full bandwidth when there is no degradation). This allows the router to reduce the bandwidth directed to the link as shown in the figure below:



When degradation in bandwidth is detected, depending on the topology, the degradation may affect one or more paths in the network. Therefore, in more complex topologies, the head-end router may need information about links in each affected path. The BNM transmission period and a Link ID are used to differentiate between messages, from the same source MAC address which refers to different links.

Restrictions for CFM Bandwidth Notifications

These are the restrictions of CFM Bandwidth Notifications:

- Up to 200 unique BNM enabled links learnt from BNMs are supported per line card. Any BNMs for links over this limit will be discarded.

  To reset CFM BNM enabled links for the specified interfaces, use the `clear ethernet cfm interface [ <interface> ] bandwidth-notifications { all | state <state> } [ location { all | <node> } ]` command. An archive timer is used to clean up any BNM enabled links whose loss timer expired at least 24 hours ago.

- Over process restart:
  - Loss threshold, wait-to-restore, and hold-off timers are restarted. This may cause links to take longer to transition between states than they would have taken otherwise.
  - Archive timers are restarted. This may cause historical statistics for links to persist longer than they would have otherwise.
  - Queued events for EEM scripts which have been rate-limited are not preserved. Scripts with at least one link in DEGRADED state, or BNMs that have changed over process restart, are invoked. Rate-limit timers are restarted. This may cause scripts to be invoked when they would otherwise have been filtered by the damping or conformance-testing algorithms. If the last link returns to its nominal bandwidth within the rate-limit period, but before the process restart, then the script will not be invoked after the process restart. Thus, actions taken by the script may not reflect the (increased) latest bandwidths of any links that returned to their nominal bandwidths within the rate-limit period.

Bandwidth Reporting

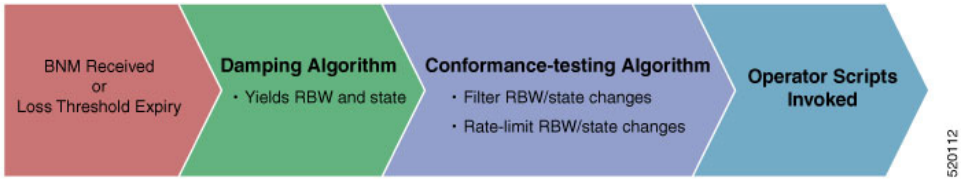
Received BNMs are used to identify BNM enabled links within a Maintenance Entity Group (MEG), and should be uniquely identifiable within the MEG by the Port-ID or MAC address. Each link has an associated nominal bandwidth and a Reported Bandwidth (RBW). These bandwidths are notified to the operator. The

link is considered to be in the OK state when the RBW is equal to the nominal bandwidth and in the DEGRADED if RBW is less than nominal.

Devices sending BNMs can detect changes in bandwidth many times in a second. For example, changes caused by an object passing through a microwave link's line of sight. The protocol for sending BNMs is designed to mitigate fluctuating current bandwidth by sampling across a 'monitoring-interval' and applying basic damping to degradation events. To help mitigate this further, a damping algorithm is used. This algorithm is applied on the receiving device, and is distinct from any damping performed by the sender. For more information, see Damping Algorithm, on page 138.

An operator may be interested in more than one BNM enabled link, and needs the ability to register on a set of BNM enabled links that affect the path to a node in the network. To do this, the state and RBW for each link of interest are put into a conformance testing algorithm, which both filters and changes the rate-limits to publish events notifying the operator only of significant changes. For more information, see Conformance Testing Algorithm, on page 139.

The following diagram shows how a received BNM flows through the damping and conformance testing algorithm to invoke operator scripts:



Note

- Port ID takes precedence over MAC address. This means that BNMs with same port ID but different MAC addresses are counted as same BNMs.
- If BNM reported bandwidth is equal to the threshold, then EEM will not be invoked.
- If a degraded link having bandwidth higher than the threshold receives BNM with bandwidth less than the threshold, it doesn't wait for the hold-off timer and instantly changes the bandwidth by invoking EEM script.

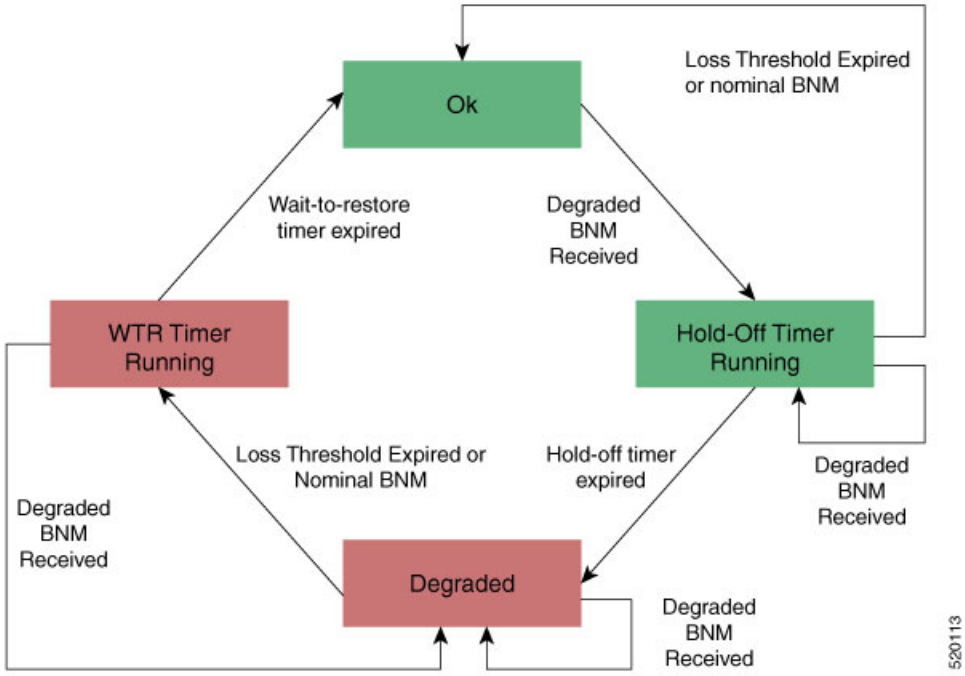
Damping Algorithm

A damping algorithm is applied to each unique BNM enabled link for which BNMs are received. The table below describes the timers used for this purpose:

Timers	Description
loss threshold (in packet numbers)	This timer handles the case when BNMs stop being received. This timer is (re)started whenever any BNM is received for the link. The value is equal to the expected period between BNMs (as indicated by the last BNM) multiplied by the configured loss threshold. When the loss threshold timer expires, as the link may have changed or been removed entirely, the bandwidth information is no longer available; therefore the link is considered to have been restored to its previously notified nominal bandwidth.

Timers	Description
hold-off (in seconds)	This timer is used to damp transient transitions from the OK state to the DEGRADED state. It is started when the first degraded BNM is received and is stopped if the loss threshold timer expires or the current bandwidth returns to the nominal bandwidth. If the timer expires, then the BNM enabled link enters the DEGRADED state. The value of this timer is configurable. If it is zero, then the link immediately enters the DEGRADED state and the timer is not started.
wait-to-restore (WTR, in seconds)	This timer is used to damp transient transitions from the DEGRADED state to the OK state. It is started when a BNM Enabled Link is in the DEGRADED state and either the loss threshold timer expires or a BNM is received, which indicates that the current bandwidth has returned to the nominal bandwidth. If a degraded BNM is received while the timer is running, then it is stopped and the BNM Enabled Link remains in DEGRADED state. If this timer expires then the link returns to OK state.

The following internal state transition diagram shows how the damping algorithm executes:



Conformance Testing Algorithm

The conformance testing algorithm comprises of two parts:

1. Filtering bandwidth changes.

   Filtering is done so that events are published whenever either:

   - Any link, which was in the OK state or had a RBW more than or equal to the specified threshold, has transitioned to the DEGRADED state and has a RBW less than the specified threshold.
   - Any link, which was in the DEGRADED state and had a RBW less than the specified threshold, is still in the DEGRADED state and has a RBW less than the specified threshold, but the old and new RBWs are different.
   - Any link, which was in the DEGRADED state and had a RBW less than the specified threshold, has transitioned to the OK state or has a RBW more than or equal to the specified threshold.

2. Rate-limiting bandwidth changes

   Rate-limiting is done by only publishing events at most once within any rate-limit period. If there is a change in bandwidth (which passes the filter) within this rate-limit period, a timer is started to expire at the end of the period. Upon timer expiry, an event is published which reflects the latest state and bandwidth of all links of interest which are in DEGRADED state.

Embedded Event Manager

The Embedded Event Manager (EEM) consists of an EEM server that monitors various real-time events in the system using programs called Event Detectors (EDs) and triggers registered policies (for example, TCLscripts) to run. The EEM supports at least 200 script registrations.

Typical actions taken in response to signal degradation events include:

- Signaling to G.8032 to switch some flows to alternative paths
- Modifying QoS configuration to adjust traffic shaping to the new bandwidth
- Adjusting IGP metrics to switch some traffic to an alternative path

The following variables can be queried within the TCL script:

EEM Variables	Comment
`interface, level, direction`	Identify the MEP in the registration
`min_reported_bandwidth`	Minimum reported bandwidth across all links in the registration that are currently in the DEGRADED state, and below the specified threshold.
`bnm_enabled_links [{ MAC address | Port ID }]`	Array of BNM enabled links, with each one containing the following elements: • `reported_bw`: Reported Bandwidth • `nominal_bw`: Nominal BW in last BNM

EEM Variables	Comment
`event_type`	Either 'DEGRADED' or 'OK' DEGRADED indicates that at least one BNM enabled link in the registration is in the DEGRADED state with a reported bandwidth less than the threshold value. This means that the `event_type` could be 'OK' if all BNM enabled links in the registration, which are in the DEGRADED state have a reported bandwidth greater than or equal to the threshold.

The command for EEM TCL scripts registering for CFM Bandwidth Notification events is `interface <interface name> level <level> direction <direction> {mac-addresses { <addr1> [, …, <addr20>] } | port-ids { <id1> [, …, <id20>] } threshold <bandwidth> [ ratelimit <time> ].`

To configure EEM, use the following commands:

```
event manager directory user policy disk0:/
event manager directory user library disk0:/
event manager policy EEMscript7.tcl username root persist-time 3600
aaa authorization eventmanager default local
```

Individual scripts located in the specified directory can then be configured with:

event manager policy <script_name> username lab persist-time <time>

Event Publishing

CFM publishes events for a given EEM registration after applying the damping and conformance testing algorithms as described in Damping Algorithm, on page 138 and Conformance Testing Algorithm, on page 139 respectively. The set of BNM Enabled Links published in an event are those in the DEGRADED state and whose RBW is less than the specified threshold.

Configuring CFM Bandwidth Notifications

Use the following steps to configure CFM bandwidth notifications:

- Configure a CFM domain at the level BNMs are expected to be received at, and a CFM service in the direction (either up or down-MEPs) the BNMs are expected to be received.
- Configure a CFM MEP on the interface expected to receive BNMs in the domain and service.

Configuration consists of two parts:

- Configuring global CFM. This is similar to Continuity Check Message (CCM) and other CFM configurations.

  Global CFM configuration:

  ```
  ethernet cfm
  domain DM1 level 2 id null
    service SR1 down-meps
    !
  !
  domain dom1 level 1
  ```

```
      service ser1 down-meps
      !
    !
```

- Configuration related to CFM-BNMs under interfaces. This is optional and used for changing default values.

Interface configuration:

```
Interface TenGigE0/0/1/1
ethernet cfm
  mep domain DM1 service SR1 mep-id 3001
  !
  bandwidth-notifications
   hold-off 0
   wait-to-restore 60
   loss-threshold 10
   log changes
  !
!
l2transport
!
!
interface TenGigE0/0/0/3
ethernet cfm
  mep domain dom1 service ser1 mep-id 11
  !
  bandwidth-notifications
  hold-off 10
   wait-to-restore 40
   log changes
  !
!
l2transport
!
!
```

Running Configuration

```
RP/0/RP0/CPU0:router#show running-configuration
!! IOS XR Configuration 7.1.1.104I
!! Last configuration change at Mon Jun 24 21:26:46 2019 by root
!
hostname R2_cXR
logging console debugging
logging buffered 125000000
event manager directory user policy harddisk:/tcl/
event manager directory user library harddisk:/tcl/
event manager policy EEMmac_lev1.tcl username root persist-time 3600
event manager policy EEMport_lev1.tcl username root persist-time 3600
aaa authorization exec default local group tacacs+
aaa authorization eventmanager default local
!
ethernet cfm
 domain DM0 level 1 id null
  service SR0 down-meps
   continuity-check interval 1m
   mep crosscheck
    mep-id 1003
   !
   ais transmission interval 1s cos 4
   log ais
   log continuity-check errors
   log crosscheck errors
```

```
   log continuity-check mep changes
  !
 !
 domain DM1 level 2 id null
  service SR1 down-meps id number 1
   continuity-check interval 1m
   mep crosscheck
    mep-id 431
   !
   ais transmission interval 1m
   log ais
   log continuity-check errors
   log crosscheck errors
   log continuity-check mep changes
  !
 domain dom1 level 3 id string domain3
  service ser1 xconnect group XG1 p2p XC1 id number 2300
   mip auto-create all
   continuity-check interval 1m
   mep crosscheck
    mep-id 2030
   !
interface Loopback0
 ipv4 address 30.30.30.30 255.255.255.255
!
interface MgmtEth0/RSP0/CPU0/0
 ipv4 address 5.18.9.102 255.255.0.0
!
interface MgmtEth0/RSP0/CPU0/1
 shutdown
!
interface TenGigE0/0/0/0
 shutdown
!
interface TenGigE0/0/0/3.1 l2transport
 encapsulation dot1q 6
 ethernet cfm
  mep domain DM1 service SR1 mep-id 231
  !
  bandwidth-notifications
   hold-off 50
   wait-to-restore 50
   loss-threshold 100
   log changes
  !
```

Verification

```
RP/0/RP0/CPU0:router#show ethernet cfm interfaces bandwidth-notifications detail
BNM Enabled Links at Level 3 (Down MEP) for GigabitEthernet/1
    MAC Address 000a.000a.000a
      State (OK):
        Nominal Bandwidth:                                  3000 Mbps
        Reported Bandwidth:                                 1000 Mbps
        Elapsed time in this state:                   00:00:13.000
        Transitions into degraded state:                      5000
        Hold-off:                                    111s remaining
      Last BNM received 00:00:10 ago
        Nominal Bandwidth:                                  1000 Mbps
        Current Bandwidth:                                  2000 Mbps
        Interval:                                             10s
        Packet-type:                                  Cisco BW-VSM
      Packets received:                                      20000

    Port ID 7 (MAC Address 000c.000c.000c)
```

```
State (DEGRADED):
  Nominal Bandwidth:                                6000 Mbps
  Reported Bandwidth:                               2000 Mbps
  Elapsed time in this state:                    00:00:39.000
  Transitions into degraded state:                      10000
  Wait-to-restore:                             111s remaining
Last BNM received 00:00:33 ago
  Nominal Bandwidth:                                2000 Mbps
  Current Bandwidth:                                4000 Mbps
  Interval:                                            1min
  Packet-type:                                  Cisco BW-VSM
Packets received:                                      40000
```