



# Using Ethernet Operations Administration and Maintenance

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Ethernet Operations, Administration, and Maintenance (OAM) is a protocol for installing, monitoring, and troubleshooting Ethernet metropolitan-area networks (MANs) and Ethernet WANs. It relies on a new, optional sublayer in the data link layer of the Open Systems Interconnection (OSI) model. The OAM features covered by this protocol are Discovery, Link Monitoring, Remote Fault Detection, Remote Loopback, and Cisco Proprietary Extensions.

The advent of Ethernet as a MAN and WAN technology has emphasized the necessity for integrated management for larger deployments. For Ethernet to extend into public MANs and WANs, it must be equipped with a new set of requirements on Ethernet's traditional operations, which had been centered on enterprise networks only. The expansion of Ethernet technology into the domain of service providers, where networks are substantially larger and more complex than enterprise networks and the user-base is wider, makes operational management of link uptime crucial.

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## Information About Using Ethernet Operations Administration and Maintenance

### Ethernet OAM

Ethernet OAM is a protocol for installing, monitoring, and troubleshooting metro Ethernet networks and Ethernet WANs. It relies on a new, optional sublayer in the data link layer of the OSI model. Ethernet OAM can be implemented on any full-duplex point-to-point or emulated point-to-point Ethernet link. A system-wide implementation is not required; OAM can be deployed for part of a system; that is, on particular interfaces.

Normal link operation does not require Ethernet OAM. OAM frames, called OAM protocol data units (PDUs), use the slow protocol destination MAC address 0180.c200.0002. They are intercepted by the MAC sublayer and cannot propagate beyond a single hop within an Ethernet network.

Ethernet OAM is a relatively slow protocol with modest bandwidth requirements. The frame transmission rate is limited to a maximum of 10 frames per second; therefore, the impact of OAM on normal operations is

negligible. However, when link monitoring is enabled, the CPU must poll error counters frequently. In this case, the required CPU cycles will be proportional to the number of interfaces that have to be polled.

Two major components, the OAM client and the OAM sublayer, make up Ethernet OAM. The following two sections describe these components.

## OAM Client

The OAM client is responsible for establishing and managing Ethernet OAM on a link. The OAM client also enables and configures the OAM sublayer. During the OAM discovery phase, the OAM client monitors OAM PDUs received from the remote peer and enables OAM functionality on the link based on local and remote state as well as configuration settings. Beyond the discovery phase (at steady state), the OAM client is responsible for managing the rules of response to OAM PDUs and managing the OAM remote loopback mode.

## OAM Sublayer

The OAM sublayer presents two standard IEEE 802.3 MAC service interfaces: one facing toward the superior sublayers, which include the MAC client (or link aggregation), and the other interface facing toward the subordinate MAC control sublayer. The OAM sublayer provides a dedicated interface for passing OAM control information and OAM PDUs to and from a client.

The OAM sublayer is made up of three components: control block, multiplexer, and packet parser (p-parser). Each component is described in the following sections.

### Control Block

The control block provides the interface between the OAM client and other blocks internal to the OAM sublayer. The control block incorporates the discovery process, which detects the existence and capabilities of remote OAM peers. It also includes the transmit process that governs the transmission of OAM PDUs to the multiplexer and a set of rules that govern the receipt of OAM PDUs from the p-parser.

### Multiplexer

The multiplexer manages frames generated (or relayed) from the MAC client, control block, and p-parser. The multiplexer passes through frames generated by the MAC client untouched. It passes OAM PDUs generated by the control block to the subordinate sublayer; for example, the MAC sublayer. Similarly, the multiplexer passes loopback frames from the p-parser to the same subordinate sublayer when the interface is in OAM remote loopback mode.

### P-Parser

The p-parser classifies frames as OAM PDUs, MAC client frames, or loopback frames and then dispatches each class to the appropriate entity. OAM PDUs are sent to the control block. MAC client frames are passed to the superior sublayer. Loopback frames are dispatched to the multiplexer.

## Benefits of Ethernet OAM

Ethernet OAM provides the following benefits:

- Competitive advantage for service providers
- Standardized mechanism to monitor the health of a link and perform diagnostics

## Cisco Implementation of Ethernet OAM

The Cisco implementation of Ethernet OAM consists of the Ethernet OAM shim and the Ethernet OAM module.

The Ethernet OAM shim is a thin layer that connects the Ethernet OAM module and the platform code. It is implemented in the platform code (driver). The shim also communicates port state and error conditions to the Ethernet OAM module via control signals.

The Ethernet OAM module, implemented within the control plane, handles the OAM client as well as control block functionality of the OAM sublayer. This module interacts with the CLI and Simple Network Management Protocol (SNMP)/programmatic interface via control signals. In addition, this module interacts with the Ethernet OAM shim through OAM PDU flows.

## OAM Features

The OAM features as defined by IEEE 802.3ah, *Ethernet in the First Mile*, are discovery, Link Monitoring, Remote Fault Detection, Remote Loopback, and Cisco Proprietary Extensions.

### Discovery

Discovery is the first phase of Ethernet OAM and it identifies the devices in the network and their OAM capabilities. Discovery uses information OAM PDUs. During the discovery phase, the following information is advertised within periodic information OAM PDUs:

- OAM mode—Conveyed to the remote OAM entity. The mode can be either active or passive and can be used to determine device functionality.
- OAM configuration (capabilities)—Advertises the capabilities of the local OAM entity. With this information a peer can determine what functions are supported and accessible; for example, loopback capability.
- OAM PDU configuration—Includes the maximum OAM PDU size for receipt and delivery. This information along with the rate limiting of 10 frames per second can be used to limit the bandwidth allocated to OAM traffic.
- Platform identity—A combination of an organization unique identifier (OUI) and 32-bits of vendor-specific information. OUI allocation, controlled by the IEEE, is typically the first three bytes of a MAC address.

Discovery includes an optional phase in which the local station can accept or reject the configuration of the peer OAM entity. For example, a node may require that its partner support loopback capability to be accepted into the management network. These policy decisions may be implemented as vendor-specific extensions.

### Link Monitoring

Link monitoring in Ethernet OAM detects and indicates link faults under a variety of conditions. Link monitoring uses the event notification OAM PDU and sends events to the remote OAM entity when there are problems detected on the link. The error events include the following:

- Error Symbol Period (error symbols per second)—The number of symbol errors that occurred during a specified period exceeded a threshold. These errors are coding symbol errors.
- Error Frame (error frames per second)—The number of frame errors detected during a specified period exceeded a threshold.

- Error Frame Period (error frames per  $n$  frames)—The number of frame errors within the last  $n$  frames has exceeded a threshold.
- Error Frame Seconds Summary (error seconds per  $m$  seconds)—The number of error seconds (1-second intervals with at least one frame error) within the last  $m$  seconds has exceeded a threshold.

Since IEEE 802.3ah OAM does not provide a guaranteed delivery of any OAM PDU, the event notification OAM PDU may be sent multiple times to reduce the probability of a lost notification. A sequence number is used to recognize duplicate events.

### Remote Failure Indication

Faults in Ethernet connectivity that are caused by slowly deteriorating quality are difficult to detect. Ethernet OAM provides a mechanism for an OAM entity to convey these failure conditions to its peer via specific flags in the OAM PDU. The following failure conditions can be communicated:

- Link Fault—Loss of signal is detected by the receiver; for instance, the peer's laser is malfunctioning. A link fault is sent once per second in the information OAM PDU. Link fault applies only when the physical sublayer is capable of independently transmitting and receiving signals.
- Dying Gasp—An unrecoverable condition has occurred; for example, when an interface is shut down. This type of condition is vendor specific. A notification about the condition may be sent immediately and continuously.

For more information on Dying Gasp, see the Dying Gasp Support for Loss of Power Supply Through SNMP, Syslog and Ethernet OAM chapter in the Cisco NCS 520 Series Router Configuration Guide.

- Critical Event—An unspecified critical event has occurred. This type of event is vendor specific. A critical event may be sent immediately and continuously.

### Remote Loopback

An OAM entity can put its remote peer into loopback mode using the loopback control OAM PDU. Loopback mode helps an administrator ensure the quality of links during installation or when troubleshooting. In loopback mode, every frame received is transmitted back on the same port except for OAM PDUs and pause frames. The periodic exchange of OAM PDUs must continue during the loopback state to maintain the OAM session.

The loopback command is acknowledged by responding with an information OAM PDU with the loopback state indicated in the state field. This acknowledgement allows an administrator, for example, to estimate if a network segment can satisfy a service-level agreement. Acknowledgement makes it possible to test delay, jitter, and throughput.

When an interface is set to the remote loopback mode the interface no longer participates in any other Layer 2 or Layer 3 protocols; for example Spanning Tree Protocol (STP) or Open Shortest Path First (OSPF). The reason is that when two connected ports are in a loopback session, no frames other than the OAM PDUs are sent to the CPU for software processing. The non-OAM PDU frames are either looped back at the MAC level or discarded at the MAC level.

From a user's perspective, an interface in loopback mode is in a link-up state.

### Cisco Vendor-Specific Extensions

Ethernet OAM allows vendors to extend the protocol by allowing them to create their own type-length-value (TLV) fields.

## OAM Messages

Ethernet OAM messages or OAM PDUs are standard length, untagged Ethernet frames within the normal frame length bounds of 64 to 1518 bytes. The maximum OAM PDU frame size exchanged between two peers is negotiated during the discovery phase.

OAM PDUs always have the destination address of slow protocols (0180.c200.0002) and an Ethertype of 8809. OAM PDUs do not go beyond a single hop and have a hard-set maximum transmission rate of 10 OAM PDUs per second. Some OAM PDU types may be transmitted multiple times to increase the likelihood that they will be successfully received on a deteriorating link.

Four types of OAM messages are supported:

- Information OAM PDU--A variable-length OAM PDU that is used for discovery. This OAM PDU includes local, remote, and organization-specific information.
- Event notification OAM PDU--A variable-length OAM PDU that is used for link monitoring. This type of OAM PDU may be transmitted multiple times to increase the chance of a successful receipt; for example, in the case of high-bit errors. Event notification OAM PDUs also may include a time stamp when generated.
- Loopback control OAM PDU--An OAM PDU fixed at 64 bytes in length that is used to enable or disable the remote loopback command.
- Vendor-specific OAM PDU--A variable-length OAM PDU that allows the addition of vendor-specific extensions to OAM.

## IEEE 802.3ah Link Fault RFI Support

The IEEE 802.3ah Link Fault RFI Support feature provides a per-port configurable option that moves a port into a blocking state when an OAM PDU control request packet is received with the Link Fault Status flag set. In the blocking state, the port can continue to receive OAM PDUs, detect remote link status, and automatically recover when the remote link becomes operational. When an OAM PDU is received with the Link Fault Status flag set to zero or FALSE, the port is enabled and all VLANs configured on the port are set to “forwarding.”



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**Note** If you configure the Ethernet OAM timeout period to be the minimum allowable value of 2 seconds, the Ethernet OAM session may be dropped briefly when the port transitions from blocked to unblocked. This action will not occur by default; the default timeout value is 5 seconds.

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Before the release of the IEEE 802.3ah Link Fault RFI Support feature, when an OAM PDU control request packet was received with the Link Fault Status flag set, one of three actions was taken:

- The port was put in the error-disable state, meaning that the port did not send or receive packets, including Bridge Protocol Data Units (BPDU) packets. In the error-disable state, a link can automatically recover after the error-disable timeout period but cannot recover automatically when the remote link becomes operational.
- A warning message was displayed or logged, and the port remained operational.
- The Link Fault Status flag was ignored.

A new keyword, **error-block-interface**, for the CLI command **ethernet oam remote-failure action** is introduced with the IEEE 802.3ah Link Fault RFI Support feature. For detailed information about this command, see the *Cisco IOS Carrier Ethernet Command Reference*.

## Ethernet Connectivity Fault Management

Ethernet connectivity fault management (CFM) is an end-to-end per-service-instance Ethernet layer OAM protocol that includes proactive connectivity monitoring, fault verification, and fault isolation. End to end can be provider edge (PE) to PE or customer edge (CE) to CE. Per service instance means per VLAN.

For more information about Ethernet CFM, see Ethernet Connectivity Fault Management .

## Understanding E-LMI and Interactions with CFM

Ethernet Local Management Interface (E-LMI) is a protocol between the customer edge (CE) device and the provider edge (PE) device. It runs only on the PE-CE UNI link and notifies the CE of connectivity status and configuration parameters of Ethernet services available on the CE port. E-LMI interoperates with an OAM protocol, such as CFM, that runs within the provider network to collect OAM status. CFM runs at the provider maintenance level (UPE to UPE with inward-facing MEPs at the UNI). E-LMI relies on the OAM Ethernet Infrastructure (EI) to interwork with CFM for end-to-end status of Ethernet virtual connections (EVCs) across CFM domains.

OAM manager streamlines interaction between OAM protocols, and handles the interaction between CFM and E-LMI. E-LMI interaction with OAM manager is unidirectional, running only from OAM manager to E-LMI on the UPE side of the switch. Information is exchanged either as a result of a request from E-LMI or triggered by OAM when it received notification of a change from the OAM protocol. This type of information is relayed:

- EVC name and availability status
- Remote UNI name and status
- Remote UNI counts

You can configure Ethernet virtual connections (EVCs), service VLANs, UNI ids (for each CE-to-PE link), and UNI count and attributes. You need to configure CFM to notify the OAM manager of any change to the number of active UNIs and or the remote UNI ID for a given S-VLAN domain.

E-LMI implementation on the Cisco ME 3400 switch includes only PE-side support.

# How to Set Up and Configure Ethernet Operations Administration and Maintenance

## Enabling Ethernet OAM on an Interface

Ethernet OAM is by default disabled on an interface.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>type number</i> <b>Example:</b>  Device(config)# interface gigabitethernet 3/8	Specifies an interface and enters interface configuration mode.
<b>Step 4</b>	<b>ethernet oam</b> [ <b>max-rate</b> <i>oampdus</i>   <b>min-rate</b> <i>num-seconds</i>   <b>mode</b> { <b>active</b>   <b>passive</b> }   <b>timeout</b> <i>seconds</i> ] <b>Example:</b>  Device(config-if)# ethernet oam	Enables Ethernet OAM.
<b>Step 5</b>	<b>exit</b> <b>Example:</b>  Device(config-if)# exit	Returns to global configuration mode.

## Disabling and Enabling a Link Monitoring Session

Link monitoring is enabled by default when you enable Ethernet OAM. Perform these tasks to disable and enable link monitoring sessions:

### Disabling a Link Monitoring Session

Perform this task to disable a link monitoring session.

**Procedure**

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

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>type number</i></b> <b>Example:</b>  Device(config)# interface gigabitEthernet 3/8	Specifies an interface and enters interface configuration mode.
<b>Step 4</b>	<b>ethernet oam [max-rate <i>oampdus</i>   min-rate <i>num-seconds</i>   mode {active   passive}   timeout <i>seconds</i>]</b> <b>Example:</b>  Device(config-if)# ethernet oam	Enables Ethernet OAM.
<b>Step 5</b>	<b>no ethernet oam link-monitor supported</b> <b>Example:</b>  Device(config-if)# no ethernet oam link-monitor supported	Disables link monitoring on the interface.
<b>Step 6</b>	<b>exit</b> <b>Example:</b>  Device(config-if)# exit	Returns to global configuration mode.

## Enabling a Link Monitoring Session

Perform this task to reenable a link monitoring session after it was previously disabled.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.



	Command or Action	Purpose
<b>Step 3</b>	<b>interface</b> <i>type number</i> <b>Example:</b>  Device(config)# interface gigabitEthernet 3/8	Specifies an interface and enters interface configuration mode.
<b>Step 4</b>	<b>ethernet oam link-monitor supported</b> <b>Example:</b>  Device(config-if)# ethernet oam link-monitor supported	Enables link monitoring on the interface.
<b>Step 5</b>	<b>exit</b> <b>Example:</b>  Device(config-if)# exit	Returns to global configuration mode.

## Stopping and Starting Link Monitoring Operations

Link monitoring operations start automatically when Ethernet OAM is enabled on an interface. When link monitoring operations are stopped, the interface does not actively send or receive event notification OAM PDUs. The tasks in this section describe how to stop and start link monitoring operations.

### Stopping Link Monitoring Operations

Perform this task to stop link monitoring operations.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>type number</i> <b>Example:</b>  Device(config)# interface gigabitethernet 3/8	Specifies an interface and enters interface configuration mode.

	Command or Action	Purpose
<b>Step 4</b>	<b>ethernet oam</b> [ <b>max-rate</b> <i>oampdus</i>   <b>min-rate</b> <i>num-seconds</i> ] <b>mode</b> { <b>active</b>   <b>passive</b> }   <b>timeout</b> <i>seconds</i> ] <b>Example:</b> Device(config-if)# ethernet oam	Enables Ethernet OAM.
<b>Step 5</b>	<b>no ethernet oam link-monitor on</b> <b>Example:</b> Device(config-if)# no ethernet oam link-monitor on	Stops link monitoring operations.
<b>Step 6</b>	<b>exit</b> <b>Example:</b> Device(config-if)# exit	Returns to global configuration mode.

## Starting Link Monitoring Operations

Perform this task to start link monitoring operations.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>type number</i> <b>Example:</b> Device(config)# interface gigabitethernet 3/8	Specifies an interface and enters interface configuration mode.
<b>Step 4</b>	<b>ethernet oam link-monitor on</b> <b>Example:</b> Device(config-if)# ethernet oam link-monitor on	Starts link monitoring operations.

	Command or Action	Purpose
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config-if)# exit	Returns to global configuration mode.

## Configuring Link Monitoring Options

Perform this optional task to specify link monitoring options. Steps 4 through 10 can be performed in any sequence.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface type number</b> <b>Example:</b> Device(config)# interface gigabitEthernet 3/8	Identifies the interface and enters interface configuration mode.
<b>Step 4</b>	<b>ethernet oam [max-rate oampdus   min-rate num-seconds] mode {active   passive}   timeout seconds]</b> <b>Example:</b> Device(config-if)# ethernet oam	Enables Ethernet OAM.
<b>Step 5</b>	<b>ethernet oam link-monitor high-threshold action error-disable-interface</b> <b>Example:</b> Device(config-if)# ethernet oam link-monitor high-threshold action error-disable-interface	Configures an error-disable function on an Ethernet OAM interface when a high threshold for an error is exceeded.
<b>Step 6</b>	<b>ethernet oam link-monitor frame {threshold {high {none   high-frames}   low low-frames}   window milliseconds}</b>	Configures a number for error frames that when reached triggers an action.

	Command or Action	Purpose
	<b>Example:</b>  Device(config-if)# ethernet oam link-monitor frame window 399	
<b>Step 7</b>	<b>ethernet oam link-monitor frame-period</b> <b>{threshold {high {none   high-frames}   low</b> <b>low-frames}   window frames}</b>  <b>Example:</b>  Device(config-if)# ethernet oam link-monitor frame-period threshold high 599	Configures a number of frames to be polled. Frame period is a user-defined parameter.
<b>Step 8</b>	<b>ethernet oam link-monitor frame-seconds</b> <b>{threshold {high {none   high-frames}   low</b> <b>low-frames}   window milliseconds}</b>  <b>Example:</b>  Device(config-if)# ethernet oam link-monitor frame-seconds window 699	Configures a period of time in which error frames are counted.
<b>Step 9</b>	<b>ethernet oam link-monitor receive-crc</b> <b>{threshold {high {high-frames   none}   low</b> <b>low-frames}   window milliseconds}</b>  <b>Example:</b>  Device(config-if)# ethernet oam link-monitor receive-crc window 99	Configures an Ethernet OAM interface to monitor ingress frames with cyclic redundancy check (CRC) errors for a period of time.
<b>Step 10</b>	<b>ethernet oam link-monitor symbol-period</b> <b>{threshold {high {none   high-symbols}   low</b> <b>low-symbols}   window symbols}</b>  <b>Example:</b>  Device(config-if)# ethernet oam link-monitor symbol-period threshold high 299	Configures a threshold or window for error symbols, in number of symbols.
<b>Step 11</b>	<b>exit</b>  <b>Example:</b>  Device(config-if)# exit	Returns to global configuration mode.

### Example

```
Device# configure terminal
```

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

```

Device(config)# interface gigabitEthernet 3/8
Device(config-if)#
Device(config-if)# ethernet oam

Device(config-if)# ethernet oam link-monitor high-threshold action error-disable-interface
Device(config-if)# ethernet oam link-monitor frame window 399
Device(config-if)# ethernet oam link-monitor frame-period threshold high 599
Device(config-if)# ethernet oam link-monitor frame-seconds window 699
Device(config-if)# ethernet oam link-monitor receive-crc window 99
Device(config-if)# ethernet oam link-monitor transmit-crc threshold low 199
Device(config-if)# ethernet oam link-monitor symbol-period threshold high 299
Device(config-if)# exit
Device# show running-config

Building configuration...
Current configuration : 5613 bytes
!
!
version 12.2
!
!
.
.
!
!
interface GigabitEthernet3/8
no ip address
ethernet oam link-monitor high-threshold action error-disable-interface
ethernet oam link-monitor frame window 399
ethernet oam link-monitor frame-period threshold high 599
ethernet oam link-monitor frame-seconds window 699
ethernet oam link-monitor receive-crc window 99
ethernet oam link-monitor transmit-crc threshold low 199
ethernet oam link-monitor symbol-period threshold high 299
ethernet oam

```

## Configuring Global Ethernet OAM Options Using a Template

Perform this task to create a template to use for configuring a common set of options on multiple Ethernet OAM interfaces. Steps 4 through 10 are optional and can be performed in any sequence. These steps may also be repeated to configure different options.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>template</b> <i>template-name</i> <b>Example:</b> <pre>Device(config)# template oam-temp</pre>	Configures a template and enters template configuration mode.
<b>Step 4</b>	<b>ethernet oam link-monitor receive-crc</b> <b>{threshold {high {high-frames   none}   low low-frames}   window milliseconds}</b> <b>Example:</b> <pre>Device(config-template)# ethernet oam link-monitor receive-crc window 99</pre>	Configures an Ethernet OAM interface to monitor ingress frames with CRC errors for a period of time.
<b>Step 5</b>	<b>ethernet oam link-monitor transmit-crc</b> <b>{threshold {high {high-frames   none}   low low-frames}   window milliseconds}</b> <b>Example:</b> <pre>Device(config-template)# ethernet oam link-monitor transmit-crc threshold low 199</pre>	Configures an Ethernet OAM interface to monitor egress frames with CRC errors for a period of time.
<b>Step 6</b>	<b>ethernet oam link-monitor symbol-period</b> <b>{threshold {high {none   high-symbols}   low low-symbols}   window symbols}</b> <b>Example:</b> <pre>Device(config-template)# ethernet oam link-monitor symbol-period threshold high 299</pre>	Configures a threshold or window for error symbols, in number of symbols.
<b>Step 7</b>	<b>ethernet oam link-monitor high-threshold action error-disable-interface</b> <b>Example:</b> <pre>Device(config-template)# ethernet oam link-monitor high-threshold action error-disable-interface</pre>	Configures an error-disable function on an Ethernet OAM interface when a high threshold for an error is exceeded.
<b>Step 8</b>	<b>ethernet oam link-monitor frame {threshold {high {none   high-frames}   low low-frames}   window milliseconds}</b> <b>Example:</b> <pre>Device(config-template)# ethernet oam link-monitor frame window 399</pre>	Configures a number for error frames that when reached triggers an action.
<b>Step 9</b>	<b>ethernet oam link-monitor frame-period</b> <b>{threshold {high {none   high-frames}   low low-frames}   window frames}</b>	Configures a number of frames to be polled. Frame period is a user-defined parameter.

	Command or Action	Purpose
	<b>Example:</b> <pre>Device(config-template)# ethernet oam link-monitor frame-period threshold high 599</pre>	
<b>Step 10</b>	<b>ethernet oam link-monitor frame-seconds</b> <b>{threshold {high {none   high-frames}   low</b> <b>low-frames}   window milliseconds}</b> <b>Example:</b> <pre>Device(config-template)# ethernet oam link-monitor frame-seconds window 699</pre>	Configures a period of time in which error frames are counted.
<b>Step 11</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-template)# exit</pre>	Returns to global configuration mode.
<b>Step 12</b>	<b>interface</b> <i>type number</i> <b>Example:</b> <pre>Device(config)# interface gigabitEthernet 3/8</pre>	Identifies the interface on which to use the template and enters interface configuration mode.
<b>Step 13</b>	<b>source template</b> <i>template-name</i> <b>Example:</b> <pre>Device(config-if)# source template oam-temp</pre>	Applies to the interface the options configured in the template.
<b>Step 14</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-if)# exit</pre>	Returns to global configuration mode.
<b>Step 15</b>	<b>exit</b> <b>Example:</b> <pre>Device(config)# exit</pre>	Returns to privileged EXEC mode.
<b>Step 16</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Displays the updated running configuration.

## Configuring a Port for Link Fault RFI Support

Perform this task to put a port into a blocking state when an OAM PDU control request packet is received with the Link Fault Status flag set.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>type number</i> <b>Example:</b> Device(config)# interface fastethernet 1/2	Enters interface configuration mode.
<b>Step 4</b>	<b>ethernet oam remote-failure {critical-event   dying-gasp   link-fault} action {error-block-interface error-disable-interface}</b> <b>Example:</b> Device(config-if)# ethernet oam remote-failure critical-event action error-block-interface Device(config-if)# ethernet oam remote-failure dying-gasp action error-disable-interface	Sets the interface to the blocking state when a critical event occurs.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config-if)# exit	Returns to global configuration mode.

## Configuring E-LMI for Interaction with CFM

For E-LMI to work with CFM, you configure Ethernet virtual connections (EVCs), Ethernet service instances (EFPs), and E-LMI customer VLAN mapping. Most of the configuration occurs on the PE switch on the interfaces connected to the CE. On the CE switch, you only need to enable E-LMI on the connecting interface. Note that you must configure some OAM parameters, for example, EVC definitions, on PE devices on both sides of a metro network.



## Default E-LMI and OAM Configuration

Ethernet LMI is globally disabled by default.

When you globally enable E-LMI by entering the **ethernet lmi global** global configuration command, it is automatically enabled on all interfaces. You can also enable or disable E-LMI per interface to override the global configuration. The command given last is the command that has precedence.

There are no EVCs, EFP service instances, or UNIs defined.

UNI bundling service is bundling with multiplexing.

## Configuration Guidelines

OAM manager is an infrastructural element and requires two interworking OAM protocols, in this case CFM and E-LMI. For OAM to operate, the PE side of the connection must be running CFM and E-LMI.

- E-LMI is supported only when the metro IP access or metro access image is running on the switch.
- You cannot configure E-LMI on VLAN interfaces.

## Enabling Ethernet OAM Remote Loopback

You must enable Ethernet OAM remote loopback on an interface for the local OAM client to initiate OAM remote loopback operations. Changing this setting causes the local OAM client to exchange configuration information with its remote peer. Remote loopback is disabled by default. Remote loopback has the following limitation:

- If dynamic ARP inspection is enabled, ARP or reverse ARP packets are not looped or dropped.

Use the **no ethernet oam remote-loopback {supported | timeout}** interface configuration command to disable remote loopback support or remove the timeout setting.

Beginning in privileged EXEC mode, follow these steps to enable Ethernet OAM remote loopback on an interface:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>	Enter global configuration mode.
<b>Step 2</b>	<b>interface</b> <i>interface-id</i>	Define an interface to configure as an EOM interface, and enter interface configuration mode.
<b>Step 3</b>	<b>ethernet oam remote-loopback {supported   timeout seconds}</b>	Enable Ethernet remote loopback on the interface or set a loopback timeout period. <ul style="list-style-type: none"> <li>• Enter supported to enable remote loopback.</li> <li>• Enter timeout seconds to set a remote loopback timeout period. The range is from 1 to 10 seconds.</li> </ul>

	Command or Action	Purpose
<b>Step 4</b>	end	Return to privileged EXEC mode.
<b>Step 5</b>	<b>ethernet oam remote-loopback</b> {start   stop} {interface <i>interface-id</i> }	Turn on or turn off Ethernet OAM remote loopback on an interface.
<b>Step 6</b>	<b>showethernet oam status</b> [interface <i>interface-id</i> ]	Verify the configuration.
<b>Step 7</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Configuring Ethernet OAM Link Monitoring

You can configure high and low thresholds for link-monitoring features. If no high threshold is configured, the default is none —no high threshold is set. If you do not set a low threshold, it defaults to a value lower than the high threshold.

The **ethernet oam link-monitor receive-crc** {threshold {high {*high-frames* | none} | low {*low-frames*}} | window *milliseconds*} command is visible on the router and you are allowed to enter it, but it is not supported. Enter the no form of the commands to disable the configuration. Use the no form of each command to disable the threshold setting.

Beginning in privileged EXEC mode, follow these steps to configure Ethernet OAM link monitoring on an interface:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>	Enter global configuration mode.
<b>Step 2</b>	<b>interface</b> <i>interface-id</i>	Define an interface, and enter interface configuration mode.
<b>Step 3</b>	<b>ethernet oam link-monitor supported</b>	Enable the interface to support link monitoring. This is the default.  You need to enter this command only if it has been disabled by previously entering the no ethernet oam link-monitor supported command.
<b>Step 4</b>	<b>ethernet oam link-monitor symbol-period</b> {threshold {high { <i>high-symbols</i>   none}   low { <i>low-symbols</i> }}   window <i>symbols</i> }	(Optional) Configure high and low thresholds for an error-symbol period that trigger an error-symbol period link event.  <ul style="list-style-type: none"> <li>Enter threshold high <i>high-symbols</i> to set a high threshold in number of symbols. The range is 1 to 65535. The default is none.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• Enter threshold high none to disable the high threshold if it was set. This is the default.</li> <li>• Enter threshold low low-symbols to set a low threshold in number of symbols. The range is 0 to 65535. It must be lower than the high threshold.</li> <li>• Enter window symbols to set the window size (in number of symbols) of the polling period. The range is 1 to 65535 symbols.</li> </ul> <p><b>Note</b> Repeat this step to configure both high and low thresholds.</p>
<b>Step 5</b>	<b>ethernet oam link-monitor frame</b> <b>{threshold {high {high-frames   none}   low {low-frames}}   window milliseconds}</b>	(Optional) Configure high and low thresholds for error frames that trigger an error-frame link event. <ul style="list-style-type: none"> <li>• Enter threshold high high-frames to set a high threshold in number of frames. The range is 1 to 65535. The default is none.</li> <li>• Enter threshold high none to disable the high threshold if it was set. This is the default.</li> <li>• Enter threshold low low-frames to set a low threshold in number of frames. The range is 0 to 65535. The default is 1.</li> <li>• Enter window milliseconds to set the a window and period of time during which error frames are counted. The range is 10 to 600 and represents the number of milliseconds in multiples of 100. The default is 100.</li> </ul> <p><b>Note</b> Repeat this step to configure both high and low thresholds.</p>
<b>Step 6</b>	<b>ethernet oam link-monitor frame-period</b> <b>{threshold {high {high-frames   none}   low {low-frames}}   window frames}</b>	(Optional) Configure high and low thresholds for the error-frame period that triggers an error-frame-period link event. <ul style="list-style-type: none"> <li>• Enter threshold high high-frames to set a high threshold in number of frames. The range is 1 to 65535. The default is none.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• Enter threshold high none to disable the high threshold if it was set. This is the default.</li> <li>• Enter threshold low low-frames to set a low threshold in number of frames. The range is 0 to 65535. The default is 1.</li> <li>• Enter window frames to set the a polling window size in number of frames. The range is 1 to 65535; each value is a multiple of 10000 frames. The default is 1000.</li> </ul> <p><b>Note</b> Repeat this step to configure both high and low thresholds.</p>
<b>Step 7</b>	<b>ethernet oam link-monitor frame-seconds</b> <b>{threshold {high {high-frames   none}   low {low-frames}}   window milliseconds}</b>	<p>(Optional) Configure high and low thresholds for the frame-seconds error that triggers an error-frame-seconds link event.</p> <ul style="list-style-type: none"> <li>• Enter threshold high high-frames to set a high error frame-seconds threshold in number of seconds. The range is 1 to 900. The default is none.</li> <li>• Enter threshold high none to disable the high threshold if it was set. This is the default.</li> <li>• Enter threshold low low-frames to set a low threshold in number of frames. The range is 1 to 900. The default is 1.</li> <li>• Enter window frames to set the a polling window size in number of milliseconds. The range is 100 to 9000; each value is a multiple of 100 milliseconds. The default is 1000.</li> </ul> <p><b>Note</b> Repeat this step to configure both high and low thresholds.</p>
<b>Step 8</b>	<b>ethernet oam link-monitor receive-crc</b> <b>{threshold {high {high-frames   none}   low {low-frames}}   window milliseconds}</b>	<p>(Optional) Configure thresholds for monitoring ingress frames received with cyclic redundancy code (CRC) errors for a period of time.</p> <ul style="list-style-type: none"> <li>• Enter threshold high high-frames to set a high threshold for the number of frames received with CRC errors. The range is 1 to 65535 frames.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• Enter threshold high none to disable the high threshold.</li> <li>• Enter threshold low low-frames to set a low threshold in number of frames. The range is 0 to 65535. The default is 1.</li> <li>• Enter window milliseconds to set the a window and period of time during which frames with CRC errors are counted. The range is 10 to 1800 and represents the number of milliseconds in multiples of 100. The default is 100.</li> </ul> <p><b>Note</b> Repeat this step to configure both high and low thresholds.</p>
<b>Step 9</b>	<code>[no] ethernet oam link-monitor on</code>	(Optional) Start or stop (when the no keyword is entered) link-monitoring operations on the interface. Link monitoring operations start automatically when support is enabled.
<b>Step 10</b>	<code>end</code>	Return to privileged EXEC mode.
<b>Step 11</b>	<code>showethernet oam status [interface interface-id]</code>	Verify the configuration.
<b>Step 12</b>	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.

## Configuration Examples for Ethernet Operations Administration and Maintenance

The following example shows how to configure Ethernet OAM options using a template and overriding that configuration by configuring an interface. In this example, the network supports a Gigabit Ethernet interface between the customer edge device and provider edge device.

```
! Configure a global OAM template for both PE and CE configuration.
!
Device(config)# template oam
Device(config-template)# ethernet oam link-monitor symbol-period threshold low 10
Device(config-template)# ethernet oam link-monitor symbol-period threshold high 100
Device(config-template)# ethernet oam link-monitor frame window 100
Device(config-template)# ethernet oam link-monitor frame threshold low 10
Device(config-template)# ethernet oam link-monitor frame threshold high 100
Device(config-template)# ethernet oam link-monitor frame-period window 100
Device(config-template)# ethernet oam link-monitor frame-period threshold low 10
Device(config-template)# ethernet oam link-monitor frame-period threshold high 100
Device(config-template)# ethernet oam link-monitor frame-seconds window 1000
Device(config-template)# ethernet oam link-monitor frame-seconds threshold low 10
```

```

Device(config-template)# ethernet oam link-monitor frame-seconds threshold high 100
Device(config-template)# ethernet oam link-monitor receive-crc window 100
Device(config-template)# ethernet oam link-monitor receive-crc threshold high 100
Device(config-template)# ethernet oam link-monitor transmit-crc window 100
Device(config-template)# ethernet oam link-monitor transmit-crc threshold high 100
Device(config-template)# ethernet oam remote-failure dying-gasp action error-disable-interface
Device(config-template)# exit
!
! Enable Ethernet OAM on the CE interface
!
Device(config)# interface gigabitethernet 4/1/1
Device(config-if)# ethernet oam
!
! Apply the global OAM template named "oam" to the interface.
!
Device(config-if)# source template oam
!
! Configure any interface-specific link monitoring commands to override the template
configuration. The following example disables the high threshold link monitoring for receive
CRC errors.
!
Device(config-if)# ethernet oam link-monitor receive-crc threshold high none
!
! Enable Ethernet OAM on the PE interface
!
Device(config)# interface gigabitethernet 8/1/1
Device(config-if)# ethernet oam
!
! Apply the global OAM template named "oam" to the interface.
!
Device(config-if)# source template oam

```

The following examples show how to verify various Ethernet OAM configurations and activities.

### Verifying an OAM Session

The following example shows that the local OAM client, Gigabit Ethernet interface Gi6/1/1, is in session with a remote client with MAC address 0012.7fa6.a700 and OUI 00000C, which is the OUI for Cisco. The remote client is in active mode and has established capabilities for link monitoring and remote loopback for the OAM session.

```

Device# show ethernet oam summary
Symbols:          * - Master Loopback State, # - Slave Loopback State
Capability codes: L - Link Monitor, R - Remote Loopback
                  U - Unidirection, V - Variable Retrieval
   Local          Remote
Interface    MAC Address    OUI    Mode    Capability
Gi6/1/1      0012.7fa6.a700 00000C active    L R

```

### Verifying OAM Discovery Status

The following example shows how to verify OAM discovery status of a local client and a remote peer:

```

Device# show ethernet oam discovery interface gigabitethernet6/1/1
GigabitEthernet6/1/1show ethernet oam discovery
Local client
-----
Administrative configurations:
Mode:          active
Unidirection: not supported

```

```

Link monitor:      supported (on)
Remote loopback:  not supported
MIB retrieval:    not supported
Mtu size:         1500
Operational status:
Port status:      operational
Loopback status:  no loopback
PDU permission:   any
PDU revision:     1
Remote client
-----
MAC address: 0030.96fd.6bfa
Vendor(oui): 0x00 0x00 0x0C (cisco)
Administrative configurations:
PDU revision:     2
Mode:             active
Unidirection:    not supported
Link monitor:    supported
Remote loopback: not supported
MIB retrieval:   not supported
Mtu size:        1500

```

### Verifying Information OAMPDU and Fault Statistics

The following example shows how to verify statistics for information OAM PDUs and local and remote faults:

```

Device# show ethernet oam statistics interface gigabitethernet6/1/1
GigabitEthernet6/1/1show ethernet oam statistics
Counters:
-----
Information OAMPDU Tx           : 588806
Information OAMPDU Rx           : 988
Unique Event Notification OAMPDU Tx : 0
Unique Event Notification OAMPDU Rx : 0
Duplicate Event Notification OAMPDU TX : 0
Duplicate Event Notification OAMPDU RX : 0
Loopback Control OAMPDU Tx      : 1
Loopback Control OAMPDU Rx      : 0
Variable Request OAMPDU Tx      : 0
Variable Request OAMPDU Rx      : 0
Variable Response OAMPDU Tx     : 0
Variable Response OAMPDU Rx     : 0
Cisco OAMPDU Tx                 : 4
Cisco OAMPDU Rx                 : 0
Unsupported OAMPDU Tx           : 0
Unsupported OAMPDU Rx           : 0
Frames Lost due to OAM         : 0
Local Faults:
-----
0 Link Fault records
2 Dying Gasp records
Total dying gasps           : 4
Time stamp                  : 00:30:39
Total dying gasps           : 3
Time stamp                  : 00:32:39
0 Critical Event records
Remote Faults:
-----
0 Link Fault records
0 Dying Gasp records
0 Critical Event records
Local event logs:
-----

```

```

0 Errored Symbol Period records
0 Errored Frame records
0 Errored Frame Period records
0 Errored Frame Second records
Remote event logs:
-----
0 Errored Symbol Period records
0 Errored Frame records
0 Errored Frame Period records
0 Errored Frame Second records

```

### Verifying Link Monitoring Configuration and Status

The following example shows how to verify link monitoring configuration and status on the local client. The highlighted Status field in the example shows that link monitoring status is supported and enabled (on).

```

Device# show ethernet oam status interface gigabitethernet6/1/1
GigabitEthernet6/1/1show ethernet oam discovery
General
-----
Mode:                active
PDU max rate:        10 packets per second
PDU min rate:        1 packet per 1 second
Link timeout:        5 seconds
High threshold action: no action
Link Monitoring
-----
Status: supported (on)
Symbol Period Error
Window:              1 million symbols
Low threshold:       1 error symbol(s)
High threshold:      none
Frame Error
Window:              10 x 100 milliseconds
Low threshold:       1 error frame(s)
High threshold:      none
Frame Period Error
Window:              1 x 100,000 frames
Low threshold:       1 error frame(s)
High threshold:      none
Frame Seconds Error
Window:              600 x 100 milliseconds
Low threshold:       1 error second(s)
High threshold:      none

```

### Verifying Status of a Remote OAM Client

The following example shows that the local client interface Gi6/1/1 is connected to a remote client. Note the values in the Mode and Capability fields.

```

Device# show ethernet oam summary
Symbols:          * - Master Loopback State, # - Slave Loopback State
Capability codes: L - Link Monitor, R - Remote Loopback
                  U - Unidirection, V - Variable Retrieval

Local              Remote
Interface          MAC Address  OUI      Mode    Capability
Gi6/1/1           0012.7fa6.a700 00000C  active  L R

```