Benefits of Ethernet OAM in Monitoring of Carrier Ethernet Services

Vladimir Settey

Cisco Expo Slovakia
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Agenda

- Introduction
- Protocols Overview
  - IEEE 802.3ah
  - IEEE 802.1ag
  - ITU-T Y.1731
  - MEF E-LMI
- OAM Interworking
- Fault Management Scenarios
- Conclusions
Drivers for Ethernet OAM

- OAM benchmarks
  - Set by TDM and existing WAN technologies

- Operational Efficiency
  - Reduce OPEX, avoid truck-rolls
  - Downtime cost

- Management Complexity
  - Large Span Networks
  - Multiple constituent networks belong to disparate organizations/companies
Problem Taxonomy

Fault Management
- Fault Detection
- Fault Verification
- Fault Isolation
- Fault Recovery
- Fault Notification

Performance Management
- Frame Loss Measurement
- Delay Measurement
- Delay Variation Measurement
- Availability Measurement

Carrier Ethernet Services

Configuration Management
- Service Provisioning
Ethernet OAM Decoded

- IEEE 802.3ah (clause 57)
  - Ethernet Link OAM
  - Also referred as 802.3 OAM, Link OAM or Ethernet in the First Mile (EFM) OAM

- IEEE 802.1ag (2007)
  - Connectivity Fault Management (CFM)
  - Also referred as Service OAM

- ITU-T Y.1731
  - OAM functions and mechanisms for Ethernet-based networks

- MEF E-LMI
  - Ethernet Local Management Interface
Ethernet OAM Building Blocks
Cisco Carrier Ethernet OAM

- Connectivity Fault Management (CFM)
- Ethernet Link OAM
- Ethernet LMI
- OAM Interworking
- IP Service Level Agreement
- Embedded Event Manager (EEM)
- MPLS OAM
Cisco CE OAM – Protocol Positioning

- E-LMI – User to Network Interface (UNI)
- Link OAM – Any point-point 802.3 link
- CFM – End-to-End UNI to UNI
- MPLS OAM – within MPLS cloud
Agenda

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  - IEEE 802.3ah
  - IEEE 802.1ag
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  - MEF E-LMI
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Link OAM (IEEE 802.3ah, Clause 57)

- Provides mechanisms useful for “monitoring link operation”, such as:
  - Link Monitoring
  - Remote Failure Indication
  - Remote Loopback Control
- Defines an optional OAM sublayer
- Intended for single point-to-point IEEE 802.3 links
- Uses “Slow Protocol” frames called OAMPDUs which are never forwarded by MAC clients
- Standardized: IEEE 802.3ah, clause 57 (now in IEEE 802.3-2005)

(1) No more than 10 frames transmitted in any one-second period
IEEE 802.3ah – Key Functions

- **OAM discovery**
  Discover OAM support and capabilities per device

- **Link monitoring**
  Basic error definitions for Ethernet so entities can detect failed and degraded connections

- **Fault signaling**
  Mechanisms for one entity to signal another that it has detected an error

- **Remote loopback**
  Used to troubleshoot networks, allows one station to put the other station into a state whereby all inbound traffic is immediately reflected back onto the link
IEEE 802.3ah

- Common, fixed header for all OAMPDUs

<table>
<thead>
<tr>
<th>Octets</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Destination Address = 01-80-c2-00-00-02</td>
</tr>
<tr>
<td>6</td>
<td>Source Address</td>
</tr>
<tr>
<td>2</td>
<td>Length / Type = 88-09 (Slow Protocols)</td>
</tr>
<tr>
<td>1</td>
<td>Subtype = 0x03 (OAM)</td>
</tr>
<tr>
<td>2</td>
<td>Flags</td>
</tr>
<tr>
<td>1</td>
<td>Code</td>
</tr>
<tr>
<td>42-1496</td>
<td>Data/Pad</td>
</tr>
<tr>
<td>4</td>
<td>FCS</td>
</tr>
</tbody>
</table>
IEEE 802.3ah – OAM Events

- Set of events that may impact link operation
- Critical Link events
  - Link Fault – Fault in the Rx direction of local DTE
  - Dying Gasp – Unrecoverable local failure condition
  - Critical Event – Unspecified critical event
- Link events
  - Errored Symbol Period Event
  - Errored Frame Event
  - Errored Frame Period Event
  - Errored Frame Seconds Summary Event
IEEE 802.3ah – Remote Loopback

- Fault localization and link performance testing
- Loopback Control OAMPDU is used to control a remote OAM client
- Traffic sent from master loopback port is loopback by slave port, except Pause and OAMPDU
Cisco E-OAM Implementation

CE

interface GigabitEthernet0/0
description To uPE11 gig2/7
eternet oam remote-loopback supported
eternet oam

Access Switch

interface GigabitEthernet2/7
description To CE11 gig0/0
eternet oam max-rate 5
eternet oam remote-loopback supported
eternet oam timeout 30
eternet oam remote-failure link-fault action error-disable-interface
eternet oam remote-failure dying-gasp action error-disable-interface
eternet oam remote-failure critical-event action error-disable-interface
eternet oam
Deploying Carrier Ethernet OAM

- **Problem Statement**
  Peer discovery and critical link event propagation between peers

- **Problem Solution**
  IEEE 802.3ah discovery and fault signaling capabilities
Deploying Carrier Ethernet OAM

- **Problem Statement**
  
  Peer discovery and critical link event propagation between peers

- **Problem Solution**
  
  IEEE 802.3ah discovery and fault signaling capabilities

---

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

<table>
<thead>
<tr>
<th>Interface</th>
<th>MAC Address</th>
<th>OUI</th>
<th>Mode</th>
<th>Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fa1/0/1</td>
<td>0014.a968.f170</td>
<td>00000C</td>
<td>active</td>
<td>L R</td>
</tr>
</tbody>
</table>
```
Deploying Carrier Ethernet OAM

- **Problem Statement**
  Peer discovery and critical link event propagation between peers

- **Problem Solution**
  IEEE 802.3ah discovery and fault signaling capabilities

---

**Example Output**

```
Jan 2 17:45:32.416: %ETHERNET_OAM-6-RFI: The client on interface Gi0/1 has received a remote failure indication from its remote peer (failure reason = remote client administratively turned off)
Jan 2 17:45:32.416: %PM-4-ERR_DISABLE: oam-remote-failure error detected on Gi0/1, putting Gi0/1 in err-disable state
```

```
Jan 2 17:54:52.520: %ETHERNET_OAM-6-RFI: The client on interface Gi0/1 has received a remote failure indication from its remote peer (failure reason = remote client reloaded)
Jan 2 17:54:52.520: %PM-4-ERR_DISABLE: oam-remote-failure error detected on Gi0/1, putting Gi0/1 in err-disable state
```
Deploying Carrier Ethernet OAM

- **Problem Statement**
  
  Link monitoring (e.g. last-mile link to CE)

- **Problem Solution**
  
  IEEE 802.3ah for link monitoring and reactive Remote Loopback capabilities
Deploying Carrier Ethernet OAM

- **Problem Statement**
  
  *Link monitoring (e.g. last-mile link to CE)*

- **Problem Solution**
  
  **IEEE 802.3ah** for link monitoring and reactive **Remote Loopback** capabilities

---

**uPE31#ethernet oam remote-loopback start interface fastEthernet 1/0/1**

This is an intrusive loopback. Therefore, while you test Ethernet OAM MAC connectivity, you will be unable to pass traffic across that link. Proceed with Remote Loopback? [confirm]

Jan 26 05:58:13.462: %ETHERNET_OAM-6-LOOPBACK: Interface Fa1/0/1 has entered the **master loopback mode**

**uPE31#show ethernet oam summary**

| Symbols: | * - Master Loopback State, # - Slave Loopback State  
| Capability codes: | L - Link Monitor, R - Remote Loopback, U - Unidirection, V - Variable Retrieval |

<table>
<thead>
<tr>
<th>Local</th>
<th>Remote</th>
<th>Interface</th>
<th>MAC Address</th>
<th>OUI</th>
<th>Mode</th>
<th>Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fa1/0/1</td>
<td>0014.a968.f170</td>
<td>00000C</td>
<td>active</td>
<td>L R</td>
</tr>
</tbody>
</table>

Javed Asghar  
ES40 Architecture  
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Cisco Confidential
Deploying Carrier Ethernet OAM

- **Problem Statement**
  
  Link monitoring (e.g. last-mile link to CE)

- **Problem Solution**

  IEEE 802.3ah for link monitoring and reactive **Remote Loopback** capabilities

---

Jan 26 05:58:13.469: %ETHERNET_OAM-6-LOOPBACK: Interface Fa0/0 has entered the slave loopback mode

CE31# show ethernet oam summary
Symbols:
* - Master Loopback State,
# - Slave Loopback State
Capability codes:
L - Link Monitor,
R - Remote Loopback,
U - Unidirectional,
V - Variable Retrieval

<table>
<thead>
<tr>
<th>Local Interface</th>
<th>MAC Address</th>
<th>OUI</th>
<th>Mode</th>
<th>Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fa0/0</td>
<td>0012.017c.3d03</td>
<td>00000C</td>
<td>active</td>
<td>L R</td>
</tr>
</tbody>
</table>
Introduction

Protocols Overview
- IEEE 802.3ah
- IEEE 802.1ag
- ITU-T Y.1731
- MEF E-LMI

OAM Interworking

Fault Management Scenarios

Conclusions
CFM Overview

- **Family of protocols** that provides capabilities to detect, verify, isolate and report end-to-end ethernet connectivity faults

- **Employs regular Ethernet frames** that travel in-band with the customer traffic
  
  Devices that cannot interpret CFM Messages forward them as normal data frames

- **CFM frames are distinguishable by Ether-Type (0x8902) and dMAC address (for multicast messages)**

- **Standardized by IEEE in late 2007**
  
  IEEE std. 802.1ag-2007
CFM Overview

- Key CFM mechanisms include:
  
  Nested **Maintenance Domains** (MDs) that break up the responsibilities for network administration of a given end-to-end service
  
  **Maintenance Associations** (MAs) that monitor service instances under a given MD
  
  **Maintenance Points** (MPs) that generate and respond to CFM PDUs
  
  **Protocols** (Continuity Check, Loopback and Linktrace) used for Fault Management activities
CFM Concepts – Maintenance Domain (MD)

- Defined by Operational/Contractual Boundaries
  - e.g. Customer/Service Provider/Operator
- MD may nest and touch, but never intersect
- Up to 8 levels of “nesting”: MD Level (0..7)
  - The higher the level, the broader its reach
- MD Name Format: null, MAC address, DNS or string-based
CFM Concepts – Maintenance Association (MA)

- Monitors connectivity of a particular service instance in a given MD (e.g. 1 service traversing 4 MDs = 4 MAs)
- Defined by a set of Maintenance End Points (MEP) at the edge of a domain
- Identified by MAID == “Short MA” Name + MD Name
- Short MA Name Format: Vlan-ID, VPN-ID, integer or string-based
CFM Concepts – MA End-Point (MEP)

- Maintenance Association End Point (MEP)
- Define the boundaries of a MD
- Support the detection of connectivity failures between any pair of MEPs in an MA
- Associated per MA and identified by a MEPID (1-8191)
- Can initiate and respond to CFM PDUs
- Maintenance Domain Intermediate Point (MIP)
- Support the discovery of paths among MEPs and location of faults along those paths
- Can be associated per MD and VLAN / EVC (manually or automatically created)
- Can add, check and respond to received CFM PDUs
CFM Concepts – UP / Inward Facing MEP

- CFM PDUs generated by the MEP are sent towards the Bridge’s Relay Function and not via the wire connected to the port where the MEP is configured.
- CFM PDUs to be responded by the MEP are expected to arrive via the Bridge’s Relay Function.
- Applicable to switches.
CFM Concepts – DOWN / Outward Facing MEP

- CFM PDUs generated by the MEP are sent via the wire connected to the port where the MEP is configured.
- CFM PDUs to be responded by the MEP are expected to arrive via the wire connected to the port where the MEP is configured.
- Port MEP – special Down MEP at level zero (0) used to detect faults at the link level (rather than service).
- Applicable to routers and switches.
CFM Concepts – MAs and UP/DOWN MEPs

- Applicability of UP/DOWN MEPs in switches:
  - DOWN MEPs are typically used for MAs spanning a single link
  - UP MEPs are commonly used for MAs with a wider reach (e.g. end-to-end, beyond a single link)
CFM Protocols

- There are three (3) protocols defined by CFM
- Continuity Check Protocol
  - Fault Detection
  - Fault Notification
- Loopback Protocol
  - Fault Verification
- Linktrace Protocol
  - Fault Isolation
CFM Protocols - Continuity Check Protocol

- Used for Fault Detection and Notification
- Per-Maintenance Association **multicast** “heart-beat” messages
  - Transmitted at a configurable periodic interval by MEPs (3.3ms, 10ms, 100ms, 1s, 10s, 1m, 10m)
  - Uni-directional (no response required)
  - Carries status of port on which MEP is configured
- Catalogued by MIPs at the same MD-Level, Terminated by remote MEPs in the same MA
## Continuity Check Protocol – Fault Detection

<table>
<thead>
<tr>
<th>Defect Name</th>
<th>Detectable Faults</th>
</tr>
</thead>
<tbody>
<tr>
<td>DefXconCCM</td>
<td>Reception by a MEP of a CCM with an incorrect MAID (cross connect error)</td>
</tr>
<tr>
<td>DefErrorCCM</td>
<td>Reception by a MEP of a CCM with an incorrect transmission interval</td>
</tr>
<tr>
<td></td>
<td>Reception by a MEP of a CCM with an incorrect MEPID (duplicate mpid error)</td>
</tr>
<tr>
<td></td>
<td>Reception by a MEP of its own CCM</td>
</tr>
<tr>
<td></td>
<td>Reception by a MEP of a CCM with an MD Level lower than that of the MEP</td>
</tr>
<tr>
<td>DefRemoteCCM</td>
<td>Inability to receive consecutive CCMs from any one of the other MEPs in its MA</td>
</tr>
<tr>
<td></td>
<td>Inability to receive CCMs from any one of the MEPs configured in a static list</td>
</tr>
<tr>
<td></td>
<td>Reception by a MEP of a CCM from a MEPs not included in a static list</td>
</tr>
<tr>
<td>DefMACstatus</td>
<td>Reception by a MEP of a CCM containing a Port Status TLV or Interface Status TLV indicating a failed port</td>
</tr>
<tr>
<td>DefRDICCM</td>
<td>Reception by a MEP of a CCM with the Remote Defect Indicator (RDI) bit set</td>
</tr>
</tbody>
</table>
CFM Protocols – Loopback Protocol

- Used for Fault Verification—Ethernet Ping
- MEP can transmit a unicast LBM to a MEP or MIP in the same MA
- Receiving MP responds by transforming the LBM into a unicast LBR sent back to the originating MEP
CFM Protocols – Linktrace protocol

- Used for Path Discovery and Fault Isolation—Ethernet Traceroute
- MEP can transmit a multicast message (LTM) in order to discover the MPs and path to a MIP or MEP in the same MA
- Each MIP along the path and the terminating MP return a unicast LTR to originating MEP
End-to-End CFM on Switchport Example

Global Configuration

### Interface Configuration

- **Interface GigabitEthernet2/7**
  - switchport trunk allowed vlan 500
  - switchport mode trunk
  - ethernet cfm mip domain Domain_L4 mpid 111 vlan 500

- **Interface GigabitEthernet2/1**
  - switchport trunk allowed vlan 500
  - switchport mode trunk
  - ethernet cfm mip level 4 vlan 500

**Global Configuration**

- ethernet cfm ieee
- ethernet cfm global
- ethernet cfm domain Domain_L4 level 4
- service customer_500_provider vlan 500
- continuity-check
- continuity-check interval 1s
- ethernet cfm logging alarm cisco
- ethernet cfm logging alarm ieee

**MD and MD Level**

- **MEP**
  - GE2/7
- **MIP**
  - GE2/1

**UNI**

- **Operator A**
- **Operator B**

**NNI**

**Manual**

- **MIP**

**Standard CFM Implementation**
End-to-End CFM on Switchport Example

Global Configuration

```
ethernet cfm ieee
ethernet cfm global
!
ethernet cfm mip auto-create level 4 vlan 500
!
```

MIPs are created on all interfaces that VLAN 500 is allowed, and VLAN 500 is not specifically associated with a Domain/Service.

NNI

interface GigabitEthernet2/1
switchport trunk allowed vlan 500
switchport mode trunk

interface GigabitEthernet2/2
switchport trunk allowed vlan 500
switchport mode trunk

Standard CFM Implementation
End-to-End CFM on Switchport Example

Global Configuration

```plaintext
ethernet cfm ieee
ethernet cfm global
!
ethernet cfm domain Domain_L4 level 4
  service customer_500_provider vlan 500
  continuity-check
  continuity-check interval 1s
  mip auto-create
!
ethernet cfm logging alarm cisco
ethernet cfm logging alarm ieee
```

MIPs are created on all interfaces where VLAN 500 is allowed at level 4
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  - IEEE 802.1ag
  - ITU-T Y.1731
  - MEF E-LMI
- OAM Interworking
- Fault Management Scenarios
- Conclusions
ITU-T Y.1731 Overview

- ITU-T recommendation that provides mechanisms for user-plane OAM functionality in Ethernet networks
  Covers:
  - Fault Management mechanisms
  - Performance Management mechanisms
- Standardized by ITU-T SG 13 in May 2006
  A new pre-published version dated February 2008 after IEEE 802.1ag standardization
- Frames format (Multicast Address, Ethertype, and common OAM PDU fields) and base functionality are generally agreed across IEEE 802.1ag and Y.1731
## ITU-T Y.1731 Terminology Vs. IEEE 802.1ag

<table>
<thead>
<tr>
<th>IEEE 802.1ag</th>
<th>ITU-T Y.1731</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ME</strong> Maintenance Entity</td>
<td>ME Maintenance Entity</td>
</tr>
<tr>
<td><strong>MA</strong> Maintenance Association</td>
<td>MEG ME Group</td>
</tr>
<tr>
<td><strong>MAID</strong> MA Identifier</td>
<td>MEGID MEG Identifier</td>
</tr>
<tr>
<td><strong>MD</strong> Maintenance Domain</td>
<td>--- No such construct available</td>
</tr>
<tr>
<td><strong>MD Level</strong> MD Level</td>
<td>MEG Level MEG Level</td>
</tr>
<tr>
<td><strong>MEP</strong> MA End Point</td>
<td>MEP MEG End Point</td>
</tr>
<tr>
<td><strong>MIP</strong> MD Intermediate Point</td>
<td>MIP MEG Intermediate Point</td>
</tr>
<tr>
<td><strong>---</strong> No such construct available</td>
<td>Server MEP Server MEP</td>
</tr>
</tbody>
</table>
ITU-T Y.1731 Overview

- **OAM Functions for Fault Management**
  - Ethernet Continuity Check (ETH-CC) *(Y.1731 adds unicast CCM)*
  - Ethernet Loopback (ETH-LB) *(Y.1731 adds multicast LBM)*
  - Ethernet Linktrace (ETH-LT)
  - Ethernet Remote Defect Indication (ETH-RDI)
  - Ethernet Alarm Indication Signal (ETH-AIS)
  - Ethernet Locked Signal (ETH-LCK)
  - In addition: ETH-TEST, ETH-APS, ETH-MCC, ETH-EXP, ETH-VSP

- **OAM Functions for Performance Management**
  - Frame Loss Measurement (ETH-LM)
  - Frame Delay Measurement (ETH-DM)
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Ethernet LMI Overview

- Provides protocol and mechanisms used for:
  - Notification of EVC addition, deletion or status (Active, Not Active, Partially Active) to CE
  - Communication of UNI and EVC attributes to CE (e.g. CE-VLAN to EVC map)
  - CE auto-configuration
  - Notification of Remote UNI name and status to CE (Cisco)

- Asymmetric protocol based on Frame Relay LMI, mainly applicable to the UNI (UNI-C and UNI-N)

- Specification completed by MEF:
Ethernet LMI

- Common, fixed header for all E-LMI PDUs
- Use of the dMAC (01-80-C2-00-00-07) requires that there is no 802.1Q compliant component between UNI-C and UNI-N

Octets

<table>
<thead>
<tr>
<th>6</th>
<th>Destination Address = 01-80-c2-00-00-07</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Source Address</td>
</tr>
<tr>
<td>2</td>
<td>Length / Type = 88-EE</td>
</tr>
<tr>
<td>46-1500</td>
<td>E-LMI PDU (Data + Pad)</td>
</tr>
<tr>
<td>4</td>
<td>FCS</td>
</tr>
</tbody>
</table>
Periodic Polling and Asynchronous Update

- Based on polling procedure invoked by CE
- N391 – Polling Counter, polling cycles between Full Status exchanges
- N393 – Status Counter, number of consecutive errors
- T391 – Polling Timer (PT), UNI-C transmits Status Enq.
- T392 – Polling Verification Timer (PVT), timer by which UNI-N expects to be polled

### ELMI-CE (UNI-C)
- A STATUS ENQ (Ethernet LMI Check)
- B STATUS (Ethernet LMI Check)
- D Restart T392
- C N391 polls sent
- E MEN Update

### ELMI-PE (UNI-N)
- A STATUS (Ethernet LMI Check)
- B STATUS (Ethernet LMI Check)
- D Restart T392
- C N391 polls sent
- E MEN Update

### EVC ASYNC Status
- A T391 Expiry
- B Restart T391
- E MEN Update
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What Is OAM Interworking?

- Strict OAM layering should be honored: messages should not cross layers
- OAM Messages should not leak outside domain boundaries within a layer
- Interworking is event translations & not necessarily 1:1 message mapping
- Interworking may be inter-layer and intra-layer
Interworking Scenarios

- Main Examples Supported by Cisco IOS

| CFM | E-LMI |
| Link OAM | CFM |
| MPLS PW OAM | E-LMI |
CFM @ Provider Level acts as MEN OAM: provides EVC Status and Remote UNI Status/Name to E-LMI

- Interface Status TLV of CC Messages carry remote UNI status
- Cisco’s Organization-specific TLV of CC Messages carry remote UNI name
- Status of remote MEP in CCDB indicates EVC State
IW Scenarios – 802.3ah to CFM (CC-based)

- Link Layer Defects detected by 802.3ah, relayed to CFM on same device
- CFM notifies remote devices of localized fault
- Two variants:
  - CC based (802.3ah on edge of domain)
  - AIS based (802.3ah within domain)
**IW Scenarios - 802.3ah to CFM (AIS-based)**

- Link Layer Defects detected by 802.3ah, relayed to CFM on same device
- CFM notifies remote devices of localized fault
- **Two variants:**
  - CC based (802.3ah on edge of domain)
  - AIS based (802.3ah within domain)
IW Scenarios - MPLS PW OAM to E-LMI

- Directed-LDP & VCCV (BFD mode) running between PEs
- D-LDP for defect notification, VCCV for defect detection
- Defects detected/communicated by PW OAM are relayed to E-LMI via I/W function on PE
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Deploying CE OAM – Ethernet L2 VPN Service

Point-to-Point Ethernet Service
Deploying CE OAM – Ethernet L2 VPN Service

OAM protocol positioning
Deploying CE OAM – Ethernet L2 VPN Service

Proactive End-to-End Service Monitoring

CFM Continuity Check Messages (CCM)

UPE11#show ethernet cfm maintenance-points remote

<table>
<thead>
<tr>
<th>MPID</th>
<th>Domain Name</th>
<th>Domain ID</th>
<th>Ingress</th>
<th>Type Id</th>
<th>Srvclnst</th>
<th>SrvcInst</th>
</tr>
</thead>
<tbody>
<tr>
<td>3100</td>
<td>PROV1_DER.DOMAIN</td>
<td>4</td>
<td>Et 0/1.100</td>
<td>VLAN 100</td>
<td>N/A</td>
<td>0s</td>
</tr>
</tbody>
</table>

Total Remote MEPs: 1
Deploying CE OAM – Ethernet L2 VPN Service

End-to-end Service / Failure Verification

uPE11# ping ethernet

CFM Loopback Message (LBM)

CFM Loopback Reply (LBR)

uPE11# ping ethernet mpid 3100 domain PROVIDER_DOMAIN vlan 100

Type escape sequence to abort.
Sending 5 Ethernet CFM Loopback messages to aabb.cc00.0599, timeout is 5 seconds
!!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/5/12 ms
Deploying CE OAM – Ethernet L2 VPN Service

Service Path Discovery / Failure Isolation

uPE11# traceroute ethernet

CFM Linktrace Message (LTM)
CFM Linktrace Reply (LTR)
Deploying CE OAM – Ethernet L2 VPN Service

Service Path Discovery / Failure Isolation

```bash
uPE11# traceroute ethernet
```

### Service Path Discovery / Failure Isolation

<table>
<thead>
<tr>
<th>Hops</th>
<th>Host</th>
<th>Forwarded</th>
<th>Egress</th>
<th>Egr Action</th>
<th>Previous</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>AGG11</td>
<td>aabb.cc00.0399</td>
<td>Et0/0.100</td>
<td>IngrOk</td>
<td>RlyMPDB</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>aabb.cc00.0299</td>
</tr>
<tr>
<td>B</td>
<td>AGG31</td>
<td>aabb.cc00.0499</td>
<td>Et0/1.100</td>
<td>EgrOk</td>
<td>RlyMPDB</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>aabb.cc00.0399</td>
</tr>
<tr>
<td>! 3</td>
<td>UPE31</td>
<td>aabb.cc00.0599</td>
<td>Et0/0.100</td>
<td>IngrOk</td>
<td>RlyHit:MEP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>aabb.cc00.0499</td>
</tr>
</tbody>
</table>

B = Intermediary Bridge
! = Target Destination
* = Per hop Timeout
Deploying CE OAM – Ethernet L2 VPN Service

CE Notification

ELMI Status Enquiry message (Full Status report)

ELMI Status message (Full Status report)

Example:

CE Notification

CE 11 uPE 11 AGG 11 AGG 31 uPE 31 CE 31

Cisco enhancements to ELMI

Local UNI ID
CE-VLAN/EVC Map type
EVC ID
EVC Type
CE-VLAN/EVC Map
EVC Status
Remote UNI count – configured
Remote UNI count – active
Remote UNI ID
Remote UNI status

CE11_UNI
Service_Multiplexing
EVC_P2P_100
Point_to_Point
vlan 100
New, Active
1
1
CE31_UNI
UP
Deploying CE OAM – Ethernet L2 VPN Service

CE Notification

ELMI Status Enquiry message (Full Status report)

ELMI Status message (Full Status report)

CE11#show ethernet lmi evc detail EVC_P2P_100
EVC Id: EVC_P2P_100
interface Ethernet0/0
  Time since Last Full Report: 00:49:01
  Ether LMI Link Status: Up
  UNI Status: Up
  UNI Id: CE11_UNI
  CE-VLAN/EVC Map Type: Service Multiplexing with no bundling
  VLAN: 100

EVC Status: Active
EVC Type: Point-to-Point
Remote UNI Count: Configured = 1, Active = 1

<table>
<thead>
<tr>
<th>UNI Id</th>
<th>UNI Status</th>
<th>Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE31_UNI</td>
<td>Up</td>
<td>Remote</td>
</tr>
</tbody>
</table>

Network Stable: Remote UNI shows UP
Deploying CE OAM – Ethernet L2 VPN Service

CE Notification – VLAN ID Mismatch

CE Configured with the **correct** C-VLAN (e.g. VID 100)

CE11(config)#interface gi 0/0.100
CE11(config-subif)#encapsulation dot1Q 100

CE11#show ip interface brief

<table>
<thead>
<tr>
<th>Interface</th>
<th>IP-Address</th>
<th>OK? Method Status</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>GigabitEthernet0/0.100</td>
<td>100.100.100.11</td>
<td>YES NVRAM up</td>
<td>up</td>
</tr>
</tbody>
</table>
Deploying CE OAM – Ethernet L2 VPN Service

CE Notification – VLAN ID Mismatch

CE Configured with the incorrect C-VLAN (e.g. vid 1300)

```
CE11(config)#interface gi0/0.100
CE11(config-subif)#encapsulation dot1Q 1300

Jan 26 00:15:39.546: %ETHER_LMI-6-MISMATCHED_VLAN_NOT_CONFIGURED: VLAN 100 not configured but in VLAN mapping for UNI GigabitEthernet0/0

Jan 26 00:15:39.546: %ETHER_LMI-6-MISMATCHED_VLAN_CONFIGURED: VLAN 1300 configured but not in VLAN mapping for UNI GigabitEthernet0/0 Interface

CE11#show ip interface brief
Interface      IP-Address      OK? Method Status                     Protocol
Gi0/0.100      100.100.100.11  YES NVRAM down                  down
```

Proactive ELMI Action at CPE
Failure Scenario: Network Failure

CFM remote MEP timeout
MEP Down (timeout) alarm
DefRemoteCCM IEEE alarm
EVC declared Inactive
CFM to ELMI Interworking

ELMI Status message
Async EVC report

ELMI action:
CE brings down
(sub)interface

Failure Scenario: Network Failure

CFM remote MEP timeout
MEP Down (timeout) alarm
DefRemoteCCM IEEE alarm
EVC declared Inactive
CFM to ELMI Interworking

ELMI Status message
Async EVC report

ELMI action:
CE brings down
(sub)interface
Deploying CE OAM – Ethernet L2 VPN Service

UPE11#

*Apr 8 04:33:44.911: %E_CFM-3-REMOTE_MEP_DOWN: Remote MEP mpid 3100 vlan 100 MA name customer_100_provider in domain PROVIDER_DOMAIN changed state to down with event code TimeOut.

*Apr 8 04:33:44.911: %ETHER_SERVICE-6-EVC_STATUS_CHANGED: status of EVC_P2P_100 changed to InActive

*Apr 8 04:33:47.587: %E_CFM-3-FAULT_ALARM: A fault has occurred in the network for the local MEP having mpid 1100 vlan 100 for service MA name customer_100_provider with the event code DefRemoteCCM

UPE11# show ethernet cfm errors

<table>
<thead>
<tr>
<th>Domain Id</th>
<th>MA Name</th>
<th>Reason</th>
<th>Type</th>
<th>Id</th>
<th>Lvl</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>3100</td>
<td>PROVIDER_DOMAIN</td>
<td>customer_100_provider</td>
<td>Mac Address</td>
<td>100</td>
<td>4</td>
<td>119s</td>
</tr>
</tbody>
</table>
Deploying CE OAM – Ethernet L2 VPN Service

UPE11#ping ethernet aabb.cc00.0599 domain PROVIDER_DOMAIN vlan 100
Type escape sequence to abort.
Sending 5 Ethernet CFM loopback messages to aabb.cc00.0599, timeout is 5 seconds
:......
Success rate is 0 percent (0/5)

UPE11#traceroute ethernet aabb.cc00.0599 domain PROVIDER_DOMAIN vlan 100
Type escape sequence to abort. TTL 64. Linktrace Timeout is 5 seconds
Tracing the route to aabb.cc00.0599 on Domain PROVIDER_DOMAIN, Level 4, vlan 100
Traceroute sent via Ethernet0/1.100, path found via MPDB

B = Intermediary Bridge
! = Target Destination
* = Per hop Timeout

<table>
<thead>
<tr>
<th>Hops</th>
<th>Host</th>
<th>MAC</th>
<th>Ingress</th>
<th>Ingr Action</th>
<th>Relay Action</th>
<th>Previous Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 1</td>
<td>AGG11</td>
<td>aabb.cc00.0399</td>
<td>Et0/0/1.100</td>
<td>IngrOk</td>
<td>RlyMPDB</td>
<td>aabb.cc00.0299</td>
</tr>
</tbody>
</table>

*
Deploying CE OAM – Ethernet L2 VPN Service

CE11#

*Apr 8 04:33:44.991: %LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet0/0.100, changed state to down

CE11#show ethernet lmi evc detail EVC_P2P_100
EVC Id: EVC_P2P_100
interface Ethernet 0/0
Time since Last Full Report: 00:01:13
Ether LM Link Status: Up
UNI Status: Up
UNI Id: CE11_UNI
CE-VLAN EVC Map Type: Service Multiplexing with no bundling
VLAN: 100

EVC Status: Inactive
EVC Type: Point-to-Point
Remote UNI Count: Configured = 1, Active = 0

<table>
<thead>
<tr>
<th>UNI Id</th>
<th>UNI Status</th>
<th>Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE31_UNI</td>
<td>Unreachable</td>
<td>Remote</td>
</tr>
</tbody>
</table>

Network Failure: Remote UNI shows UNREACHABLE
Deploying CE OAM – Ethernet L2 VPN Service

Failure Scenario: UNI Link Down

- ELMI Status message: Async EVC report
- ELMI action: CE brings down (sub)interface
- CFM MEP Up (port state Down) alarm
- DefMACstatus IEEE alarm
- EVC declared Inactive
- CFM to ELMI InterWorking
- EVC declared Inactive
- CFM CCM Interface Status TLV “isDown”
Deploying CE OAM – Ethernet L2 VPN Service

UPE11#

*Apr  8 04:41:54.823: %E_CFM-6-REMOTE_MEP_UP: Continuity Check message is received from a remote MEP with mpid 3100 vlan 100 MA name customer_100_provider domain PROVIDER_DOMAIN interface status Down event code PortState.

*Apr  8 04:41:54.823: %ETHER_SERVICE-6-EVC_STATUS_CHANGED: status of EVC_P2P_100 changed to InActive

*Apr  8 04:41:57.451: %E_CFM-3-FAULT_ALARM: A fault has occurred in the network for the local MEP having mpid 1100 vlan 100 for service MA name customer_100_provider with the event code DefMACstatus.

UPE11#show ethernet cfm maintenance-point remote

<table>
<thead>
<tr>
<th>MPID</th>
<th>Domain Name</th>
<th>Domain ID</th>
<th>MA Name</th>
<th>Type Id</th>
<th>SrvcInst</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>3100</td>
<td>PROVIDER_DOMAIN</td>
<td>4</td>
<td>-</td>
<td>customer_100_provider</td>
<td>VLAN 100</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Total Remote MEPs: 1
Deploying CE OAM – Ethernet L2 VPN Service

CE 11 #

*Apr  8 04:41:54.907: %LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet0/0.100, changed state to down

CE 11 # show ethernet lmi evc detail EVC_P2P_100

EVC Id: EVC_P2P_100
interface Ethernet0/0
Time since Last Full Report: 00:01:07
Ether LMI Link Status: Up
UNI Status: Up
UNI Id: CE11_UNI
CE-VLAN/ EVC Map Type: Service Multiplexing with no bundling
VLAN: 100

EVC Status: Inactive
EVC Type: Point-to-Point
Remote UNI Count: Configured = 1, Active = 0

UNI Id: UNI Status: Port
------ -------- -----
CE31_UNI  Down  Remote

UNI Failure: Remote UNI shows DOWN
Deploying CE OAM – Ethernet L2 VPN Service

Failure Scenario: UNI Admin Shutdown

- CE transmits 802.3ah Dying Gasp
- 802.3ah alarm
- EVC declared Inactive
- 802.3ah to CFM InterWorking

- CFM MEP Up (port state AdminDown) alarm
  - DefMACstatus IEEE alarm
  - EVC declared Inactive
  - CFM to ELMI InterWorking

- ELMI Status message
  - Async EVC report

- ELM action: CE brings down (sub)interface

- CE transmits UNI admin Shutdown at CE

- UNI admin Shutdown at CE

- Cisco enhancement to CFM

- CFM CCM
  - Organization-specific TLV
  - AdminDown
Deploying CE OAM – Ethernet L2 VPN Service

Failure Scenario: Power Failure at CE

Power lost at CE site

CE transmits Power Failure

802.3ah Dying Gasp

802.3ah alarm
EVC declared Inactive
802.3ah to CFM InterWorking

CFM CCM Interface Status TLV “isDown”

CFM MEP Up (port state Down) alarm
DefMACstatus IEEE alarm
EVC declared Inactive
CFM to ELMI InterWorking

ELMI Status message
Async EVC report

ELMI action:
CE brings down (sub)interface
Deploying CE OAM – Ethernet L2 VPN Service

Failure Scenario: UNI Errors (Detected by CE)

CE exceeds 802.3ah HIGH error threshold
CE sends 802.3ah Event OAM PDUs

ELMI action: CE brings down (sub)interface
ELMI Status message
Async EVC report

CFM MEP Up (port state remoteExcessiveErrors) alarm
EVC declared Inactive
CFM to ELMI InterWorking

802.3ah to CFM InterWorking
EVC declared Inactive

CFM CCM Organization-specific TLV remoteExcessiveErrors
Cisco enhancement to CFM

Receive Errors detected by CE

Failure Scenario: UNI Errors (Detected by CE)
Failure Scenario: UNI Errors (detected by SP)

- **SP exceeds 802.3ah HIGH error threshold**
- **SP sends 802.3ah Event OAM PDUs**
- **ELMI action**: CE brings down (sub)interface
- **ELMI Status message**: Async EVC report
- **CFM MEP Up (port state localExcessiveErrors) alarm**
- **EVC declared Inactive**
- **CFM to ELMI InterWorking**
- **802.3ah to CFM InterWorking**
- **EVC declared Inactive**
- **CFM CCM Organization-specific TLV localExcessiveErrors**
- **Receive Errors detected by SP**

Cisco enhancement to CFM
Agenda

- Introduction
- Protocols Overview
  - IEEE 802.3ah
  - IEEE 802.1ag
  - ITU-T Y.1731
  - MEF E-LMI
- OAM Interworking
- Fault Management Scenarios
- Conclusions
Cisco CE OAM – Platform Support

Customer Premise

Access

Cisco 1800/2800/3800
Cisco 7200/7201/7301
Cisco ME3400
Cisco ME3400E
Catalyst 3750-ME

Aggregation

Catalyst 6500
Catalyst 4500
Cisco ONS 15454
Cisco 7600
E-OAM Documentation at Cisco.com

- Ethernet Operations, Administration and Maintenance— White Paper
- IOS 12.2SR, 12.2SX, 12.4T – Connectivity Fault Management (CFM)
- IOS 12.2SR, 12.2SX, 12.4T – Link OAM
- IOS 12.2SR – Y.1731 AIS and RDI
- IOS 12.2SR, 12.2SX – Ethernet Local Management Interface (E-LMI)
- IOS 12.4T – Ethernet Local Management Interface (E-LMI)
- IOS 12.2SR, 12.2SX, 12.4T – IP SLA for Metro Ethernet
- IOS 12.2SR—EoMPLS Remote Link Failure Notification via E-LMI (aka Remote Port Shutdown)
E-OAM Information at Cisco.com

- **IOS 12.2SE—Cisco ME 3400 CFM, E-LMI and Link OAM**

- **IOS 12.2SE—Cisco Catalyst 3750-ME CFM, E-LMI and Link OAM**

- **IOS 12.2SG—Cisco Catalyst 4500 CFM and Link OAM**

- **IOS 12.2SG—Cisco Catalyst 4500 Y.1731 AIS and RDI**

- **Release 9.0 —Cisco ONS 15454 ML-MR-10 CFM, E-LMI and Link OAM**