Understanding the Benefits of Ethernet OAM

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Agenda

- Protocol Overview
  - IEEE 802.3ah (clause 57)
  - IEEE 802.1ag
  - ITU Y.1731
  - MEF E-LMI

- OAM Inter-Working

- Fault Management scenarios

- Performance Management
Ethernet OAM Protocol Overview
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
Decoder Ring

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

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

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

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

- Fault Management
- Performance Management
- Configuration Management

Service Layer
Network Layer
Transport Layer

802.3ah
802.1ag / Y.1731
E-LMI

Cisco IP SLAs
Cisco Carrier Ethernet OAM

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

IEEE 802.3ah (Clause 57)
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
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
Connectivity Fault Management (CFM)

IEEE 802.1ag
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.
CFM Overview (Cont.)

- 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
Maintenance Domain Nesting
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
Maintenance Point (MP)—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
CFM Concepts
Maintenance Point (MP)—MIP

- **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
## CFM Protocols
### 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
CFM Protocols
Putting Everything Together

1. Run Connectivity Check to proactively detect a soft or hard failure
2. Upon a failure detection, use Loopback to verify it
3. Upon verification, run Traceroute to isolate it; multiple segment LPs can also be used to isolate the fault
4. If the isolated fault points to a virtual circuit, then the OAM tools for that technology can be used to further fault isolation—e.g., for MPLS PW, VCCV and MPLS ping can be used
Troubleshooting: Example

'Uncertainty' Zone shrinks with every lower level Domain

Defect Locality Zone

Defect successfully isolated

Loopback & Link Trace Tests

Customer Domain

Service Provider Domain

Operator Domains
CFM Deployment
Scenario A

- End to End service provided over a single Administrative Domain (e.g. Carrier A)
CFM Deployment
Scenario A (Cont.)

End to End Customer service monitoring (optional)
End to End SP service monitoring
Port MEPs
First mile link monitoring
CFM Deployment
Scenario B

- End to End service provided by a SP (e.g. Carrier A) who relies on another SP access network (e.g. Carrier B) to reach some customer sites
CFM Deployment
Scenario B (Cont.)

Customer Domain
Operator Domain
Link Domain

End to End Customer service monitoring (optional)

Independent Operator service monitoring

Port MEPs
E-NNI link monitoring

MEP
MIP
Connectivity Fault Management (CFM)
Cisco IOS CFM Implementation

Cisco IOS Details

- IEEE 802.1ag supported across the CE / CPE, Access and Aggregation product lines
- CFM IOS shipping implementation is based on IEEE 802.1ag draft 1.0 (circa 2004)
  - Procedural and Frame changes prevent interoperability with standard-based CFM implementations
- Support for standard IEEE 802.1ag-2007 is scheduled for Q3-Q4 CY 2009
  - Cisco IOS Area Edge Bridge (AEB) feature performs message translation to allow interoperability between draft 1.0 and standard CFM
- All three (3) IEEE 802.1ag protocols supported:
  - Continuity Check, Loopback and Linktrace
Cisco IOS CFM Implementation
Cisco IOS Details (Cont.)

CFM Deployment Scenarios

CFM on Switchport

CFM on Routed Port

CFM on Service Instance with Bridge Domain

EXAMPLE:

interface GigabitEthernet2/2
switchport trunk allowed vlan 500
switchport mode trunk
ethernet cfm mep ...
ethernet cfm mep ...

interface GigabitEthernet2/2
ethernet cfm mep ...
interface GigabitEthernet2/2.500
encapsulation dot1q 500
ip address 1.1.1.1 255.255.0.0

interface GigabitEthernet2/2
service instance 1 ethernet
encapsulation dot1q 500
bridge-domain 100
cfm mip ...
cfm mep ...
Cisco IOS CFM Implementation
Cisco IOS Details (Cont.)

CFM Deployment Scenarios

CFM on Service Instance with Xconnect

EXAMPLE:

interface GigabitEthernet2/2
service instance 1 ethernet
encapsulation dot1q 500
xconnect 2.2.2.2 111 ...
cfm mip ...
cfm mep ...

CFM on L2 VFI

l2 vfi blue manual
vpn id 100
bridge-domain 10 vlan
neighbor 11.0.0.1 ...
neighbor 11.0.0.2 ...
cfm mep ...
Cisco CFM Implementation
End-to-End CFM on Switchport Example

Global Configuration

Interface GigabitEthernet2/1
  switchport trunk allowed vlan 500
  switchport mode trunk
  ethernet cfm mep domain Domain_L4 mpid 111 vlan 500

MD and MD Level

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

Manual MIP

 MEP

 CE

 Operator A

 Operator B

 CE

 UNI

 NNI

 Standard CFM Implementation
Cisco CFM Implementation
End-to-End CFM on Switchport example (Cont.)

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.

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

interface GigabitEthernet2/2
switchport trunk allowed vlan 500
switchport mode trunk
Cisco CFM Implementation
End-to-End CFM on Switchport example (Cont.)

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
  - 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

interface GigabitEthernet3/2
switchport trunk allowed vlan 500
switchport mode trunk
ethernet cfm mep domain Domain_L4 mpid 222 vlan 500

interface GigabitEthernet3/1
switchport trunk allowed vlan 500
switchport mode trunk
ethernet cfm mep domain Domain_L4 level 4 service customer_500_provider vlan 500 continuity-check continuity-check interval 1s mip auto-create
OAM Functions and Mechanisms for Ethernet-Based Networks

ITU-T Y.1731
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 Feb. 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
Comparison with IEEE 802.1ag

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

MEF-16
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

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

Ethernet LMI
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

status (EVC ASYNC Status)

status (Full Status Resp)
STATUS ENQ (Full Status Req)

status (Ethernet LMI Check)

status (Ethernet LMI Check)
STATUS ENQ (Ethernet LMI Check)

status (Ethernet LMI Check)
STATUS ENQ (Ethernet LMI Check)

status (Ethernet LMI Check)

status (Ethernet LMI Check)
Ethernet OAM Interworking
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
Interworking Scenarios

CFM to 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
Interworking 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)
Interworking 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)
Interworking 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
Fault Management Scenarios
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Point-to-Point Ethernet Service
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

OAM protocol positioning
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Proactive End-to-End Service Monitoring

CFM Continuity Check Messages (CCM)

```
UPE11# show ethernet cfm maintenance-points remote
-----------------------------------------------
MPID  Domain Name       MacAddress     IfSt  PtSt
Lvl  Domain ID          Ingress       Type Id  SrvcInst
RDI  MA Name            EVC Name       Age
-----------------------------------------------
3100  PROVIDER_DOMAIN   aabb.cc00.0599 Up  Up
  4  PROVIDER_DOMAIN    E10/1.100      N/A
    • customer_100_provider VLAN 100 N/A
        N/A
-----------------------------------------------
Total Remote MEPs: 1
```
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

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 Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Service Path Discovery/Failure Isolation

uPE11# traceroute ethernet

CFM Linktrace Message (LTM)
CFM Linktrace Reply (LTR)
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Service Path Discovery/Failure Isolation

uPE11# traceroute ethernet

---

**B** = Intermediary Bridge

**!** = Target Destination

**= Per hop Timeout**

<table>
<thead>
<tr>
<th>MAC</th>
<th>Ingress</th>
<th>Ingr Action</th>
<th>Relay</th>
</tr>
</thead>
<tbody>
<tr>
<td>**---</td>
<td>---------</td>
<td>-------------</td>
<td>-------</td>
</tr>
<tr>
<td><strong>B</strong> 1</td>
<td>AGG11</td>
<td>aabb.cc00.0399</td>
<td>Et0/0.100</td>
</tr>
<tr>
<td></td>
<td>Forwarded</td>
<td>Et0/1.100</td>
<td>EgrOK</td>
</tr>
<tr>
<td><strong>B</strong> 2</td>
<td>AGG31</td>
<td>aabb.cc00.0499</td>
<td>Et0/0.100</td>
</tr>
<tr>
<td></td>
<td>Forwarded</td>
<td>Et0/1.100</td>
<td>EgrOK</td>
</tr>
<tr>
<td><strong>!</strong> 3</td>
<td>UPE31</td>
<td>aabb.cc00.0599</td>
<td>Et0/0.100</td>
</tr>
<tr>
<td></td>
<td>Not Forwarded</td>
<td>aabb.cc00.0499</td>
<td></td>
</tr>
</tbody>
</table>

uPE11# traceroute ethernet mpid 3100 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
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

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

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

Cisco enhancements to
ELMI

CE11_UNI
Service_Multiplexing
EVC_P2P_100
Point_to_Point
vlan 100
New, Active
1
1
CE31_UNI
UP
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE Notification

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

  UNI Id  UNI Status  Port
  -------  ----------  -----  
  CE31_UNI  Up  Remote

ELMI Status Enquiry message (Full Status report)

ELMI Status message (Full Status report)

Network Stable:
Remote UNI shows UP
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE Notification—VLAN ID Missmatch

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

CE11(config)#interface gig0/0.100
CE11(config-subif)#encapsulation dot1Q 100

CE11#show ip interface brief
Interface     IP-Address  OK? Method Status     Protocol
GigabitEthernet0/0.100  100.100.100.11 YES NVRAM up          up
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE Notification—VLAN ID Missmatch

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

CE11(config)#interface gig0/0.100
CE11(config-subif)#encapsulation dot1Q 1300

Jan 26 00:15:39.546: %ETHER_LMI-6-MISMATCHED_VLAN_NOTCONFIGURED: 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
GigabitEthernet0/0.100 100.100.100.11 YES NVRAM down down

Proactive ELMI Action at CPE
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

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

- 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 Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

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>MPID</th>
<th>Domain Id</th>
<th>MAName</th>
<th>Mac Address</th>
<th>Type</th>
<th>Id</th>
<th>Lvl</th>
<th>Reason</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>3100</td>
<td>PROVIDER_DOMAIN</td>
<td>customer_100_provider</td>
<td>aabb.cc00.0599</td>
<td>Vlan</td>
<td>100</td>
<td>4</td>
<td>Lifetime Timer Expired</td>
<td>119s</td>
</tr>
</tbody>
</table>

Error DB

Cisco-defined alarm

IEEE-defined alarm
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

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

+---------------------------------+-----------------+-----------------+-----------------+-----------------+
| Hops | MAC      | Ingress Host | Ingr Action    | Relay Action   |
+---------------------------------+-----------------+-----------------+-----------------+-----------------+
|      | aabb.cc00.0399 Et0/0.100 | IngOk          | RlyMPDB        |                |
|      | Forwarded Et0/1.100       | EgrOK          | aabb.cc00.0299 |                |
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

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

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 Ethernet0/0
  Time since Last Full Report: 00:01:13
  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     Unreachable  Remote

Network Failure: Remote UNI shows UNREACHABLE
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Failure Scenario: UNI Link Down

- ELMI action: CE brings down (sub)interface
- ELMI Status message
- Async EVC report
- CFM MEP Up (port state Down) alarm
- DefMACstatus IEEE alarm
- EVC declared Inactive
- CFM to ELMi InterWorking
- CFM CCM Interface Status TLV "isDown"
- EVC declared Inactive
- UNI Link Down
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

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>MacAddress</th>
<th>IfSt</th>
<th>PtSt</th>
</tr>
</thead>
<tbody>
<tr>
<td>3100</td>
<td>PROVIDER_DOMAIN</td>
<td>aabb.cc00.0599</td>
<td>Down</td>
<td>Up</td>
</tr>
<tr>
<td>4</td>
<td>PROVIDER_DOMAIN</td>
<td>E0/1.100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>customer_100_provider</td>
<td>Vlan 100</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Remote MEPs: 1
**Deploying Carrier Ethernet OAM**

**Ethernet Layer 2 VPN Services**

---

CE11#

*Apr  8 04:41:54.907: %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 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

<table>
<thead>
<tr>
<th>UNI Id</th>
<th>UNI Status</th>
<th>Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE31_UNI</td>
<td>Down</td>
<td>Remote</td>
</tr>
</tbody>
</table>
Failure Scenario: UNI Admin Shutdown

ELMI action:
CE brings down (sub)interface

ELMI Status message
Async EVC report

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

Cisco enhancement to CFM

UNI admin Shutdown at CE

CFM CCM
Organization-specific TLV AdminDown
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Failure Scenario: Power Failure at CE

- **ELMI action:** CE brings down (sub)interface
- **ELMI Status message:** Async EVC report
- **CFM MEP Up (port state Down) alarm**
- **DefMACstatus IEEE alarm**
- **EVC declared Inactive**
- **CFM to ELMI InterWorking**
- **CE transmits Power Failure 802.3ah Dying Gasp**
- **802.3ah alarm**
- **EVC declared Inactive**
- **802.3ah to CFM InterWorking**
- **Power lost at CE site**
- **CFM CCM Interface Status TLV “isDown”**
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Failure Scenario: UNI Errors (Detected by CE)

<table>
<thead>
<tr>
<th>CE</th>
<th>Access</th>
<th>Aggregation</th>
<th>Aggregation</th>
<th>Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE exceeds 802.3ah HIGH error threshold</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE sends 802.3ah Event OAM PDUs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>802.3ah to CFM InterWorking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVC declared Inactive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFM MEP Up (port state remoteExcessiveErrors) alarm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVC declared Inactive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFM to ELMI InterWorking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELMI Status message Async EVC report</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVC declared Inactive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFM CCM Organization-specific TLV remoteExcessiveErrors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cisco enhancement to CFM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELMI action: CE brings down (sub)interface</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receive Errors detected by CE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Failure Scenario:

- UNI Errors (Detected by CE)
  - Receive Errors detected by CE
  - 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
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Failure Scenario: UNI Errors (detected by SP)

- 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
- SP exceeds 802.3ah HIGH error threshold
- SP sends 802.3ah Event OAM PDUs
- CFM CCM Organization-specific TLV localExcessiveErrors
- Receive Errors detected by SP
- Cisco enhancement to CFM
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Point-to-Point Ethernet Service
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

OAM Protocol Positioning
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Failure Scenario: UNI Failure

CE UNI failure: Admin "shutdown"

ELMI Status message
Async EVC report

ELMI action:
CE brings down (sub)interface

EVC declared Inactive
PW declared DOWN (syslog)

Tx LDP TLV Status
(PW status: AC DOWN)

PW declared DOWN (syslog)
EVC declared Inactive (syslog)

PW OAM to ELMI InterWorking
Ethernet Performance Management

IP SLAs
IP SLAs
Performance Management

- IP SLAs Embedded Policy Management
  Scheduling Automation/Policy Alerts/Data Collection
- In-band Performance Management Tool for Ethernet
  Delay, Delay Variation and Packet Loss measurement
  Built in CFM principles
- Automatic Discovery of Probe Endpoints
**IP SLA**

CFM Integration Highlights

- **In-band Performance Management Tool for Ethernet**
  - Use native Ethernet frames
  - IP not required

- **Built over CFM**
  - Use Ethernet CFM frames to collect statistics
  - Probes performed in context of a VLAN and a CFM Maintenance Domain
  - CFM MEPs define probe endpoints

- **Automatic Discovery of Probe Endpoints**
  - Rely on CFM Continuity Check Database (CCDB) to automatically discover Probe Endpoints
  - EVC and Maintenance Domain based
  - Support ‘static’ probes and exclusions
## IP SLA

### Ethernet Probe Types

<table>
<thead>
<tr>
<th>Probe Type</th>
<th>Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echo Probe</td>
<td>Per service, ethernet probe, Uses CFM LBM/LBR PDUs, Measures RTT</td>
</tr>
<tr>
<td>Jitter Probe</td>
<td>Per service, ethernet probe, Uses proprietary CFM messages, Measures uni-directional packet loss, jitter and latency</td>
</tr>
</tbody>
</table>
IP SLA
Hierarchical Performance Management

- SLA measurement operations in one domain are transparent to higher/lower domains
- Allows for ‘segmented’, ‘composite’ and ‘end-to-end’ measurements
- Follows CFM Maintenance Domain Hierarchical Model: Customer, Service Provider, Operator

MEP
- Probe initiation/end point
- Auto-discovers all other MEPs in Domain/VLAN
IP SLA
Probe Endpoint Auto Discovery

- Probe endpoints dynamically discovered for given VLAN within a Maintenance Domain
- New probes automatically created for newly added endpoints (sites)

Only need to configure new site CE for CFM,
No changes to existing sites for SLA measurement.
# Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS</td>
<td>Alarm Indication Signal</td>
</tr>
<tr>
<td>CCM</td>
<td>Continuity Check Message</td>
</tr>
<tr>
<td>CCMDB</td>
<td>CCM Data Base (see CCM)</td>
</tr>
<tr>
<td>CE</td>
<td>Customer Edge</td>
</tr>
<tr>
<td>CFM</td>
<td>Connectivity Fault Management</td>
</tr>
<tr>
<td>EFM</td>
<td>Ethernet in the First Mile</td>
</tr>
<tr>
<td>E-LMI</td>
<td>Ethernet LMI (see LMI)</td>
</tr>
<tr>
<td>E-OAM</td>
<td>Ethernet OAM (see OAM)</td>
</tr>
<tr>
<td>EVC</td>
<td>Ethernet Virtual Connection</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>ITU</td>
<td>International Telecommunication Union</td>
</tr>
<tr>
<td>LBM</td>
<td>Loopback Message</td>
</tr>
<tr>
<td>LBR</td>
<td>Loopback Reply</td>
</tr>
<tr>
<td>LMI</td>
<td>Local Management Interface</td>
</tr>
<tr>
<td>LTM</td>
<td>Linktrace Message</td>
</tr>
<tr>
<td>LTR</td>
<td>Linktrace Reply</td>
</tr>
<tr>
<td>MA</td>
<td>Maintenance Association</td>
</tr>
<tr>
<td>MAID</td>
<td>MA Identifier (see MA)</td>
</tr>
<tr>
<td>MD</td>
<td>Maintenance Domain</td>
</tr>
<tr>
<td>MEF</td>
<td>Metro Ethernet Forum</td>
</tr>
<tr>
<td>MEN</td>
<td>Metro Ethernet Network</td>
</tr>
<tr>
<td>MEP</td>
<td>Maintenance Association End Point</td>
</tr>
<tr>
<td>MEPID</td>
<td>MEP Identifier (see MEP)</td>
</tr>
<tr>
<td>MHF</td>
<td>MIP Half Function (see MIP)</td>
</tr>
<tr>
<td>MIB</td>
<td>Management Information Base</td>
</tr>
<tr>
<td>MIP</td>
<td>Maintenance Domain Intermediate Point</td>
</tr>
<tr>
<td>MP</td>
<td>Maintenance Point</td>
</tr>
<tr>
<td>OAM</td>
<td>Operations, Administration and Maintenance</td>
</tr>
<tr>
<td>PDU</td>
<td>Protocol Data Unit</td>
</tr>
<tr>
<td>PE</td>
<td>Provide Edge</td>
</tr>
<tr>
<td>RDI</td>
<td>Remote Defect Indicator</td>
</tr>
<tr>
<td>RFI</td>
<td>Remote Failure Indicator</td>
</tr>
<tr>
<td>TLV</td>
<td>Type, Length, Value</td>
</tr>
<tr>
<td>UNI</td>
<td>User to Network Interface</td>
</tr>
<tr>
<td>UNI-C</td>
<td>Customer side of UNI (see UNI)</td>
</tr>
<tr>
<td>UNI-N</td>
<td>Network side of UNI (see UNI)</td>
</tr>
<tr>
<td>VID</td>
<td>VLAN Identifier</td>
</tr>
<tr>
<td>VLAN</td>
<td>Virtual LAN</td>
</tr>
</tbody>
</table>
Q and A
Acknowledgement

- Jose Liste, TME-Cisco Systems