Understanding the Benefits of Ethernet OAM

Santanu Dasgupta

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

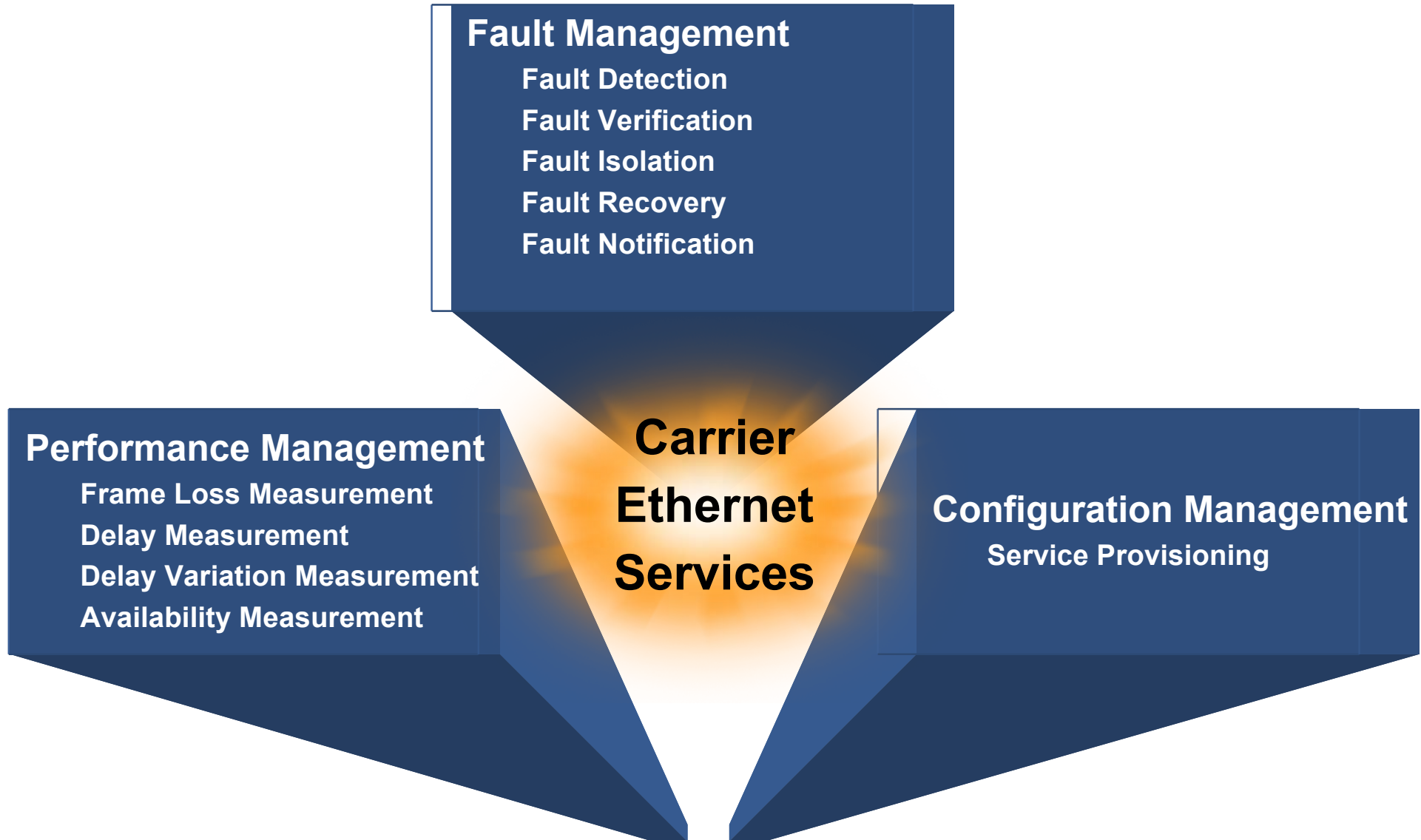- ## Operational Efficiency

  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**

Carrier Ethernet Services

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

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
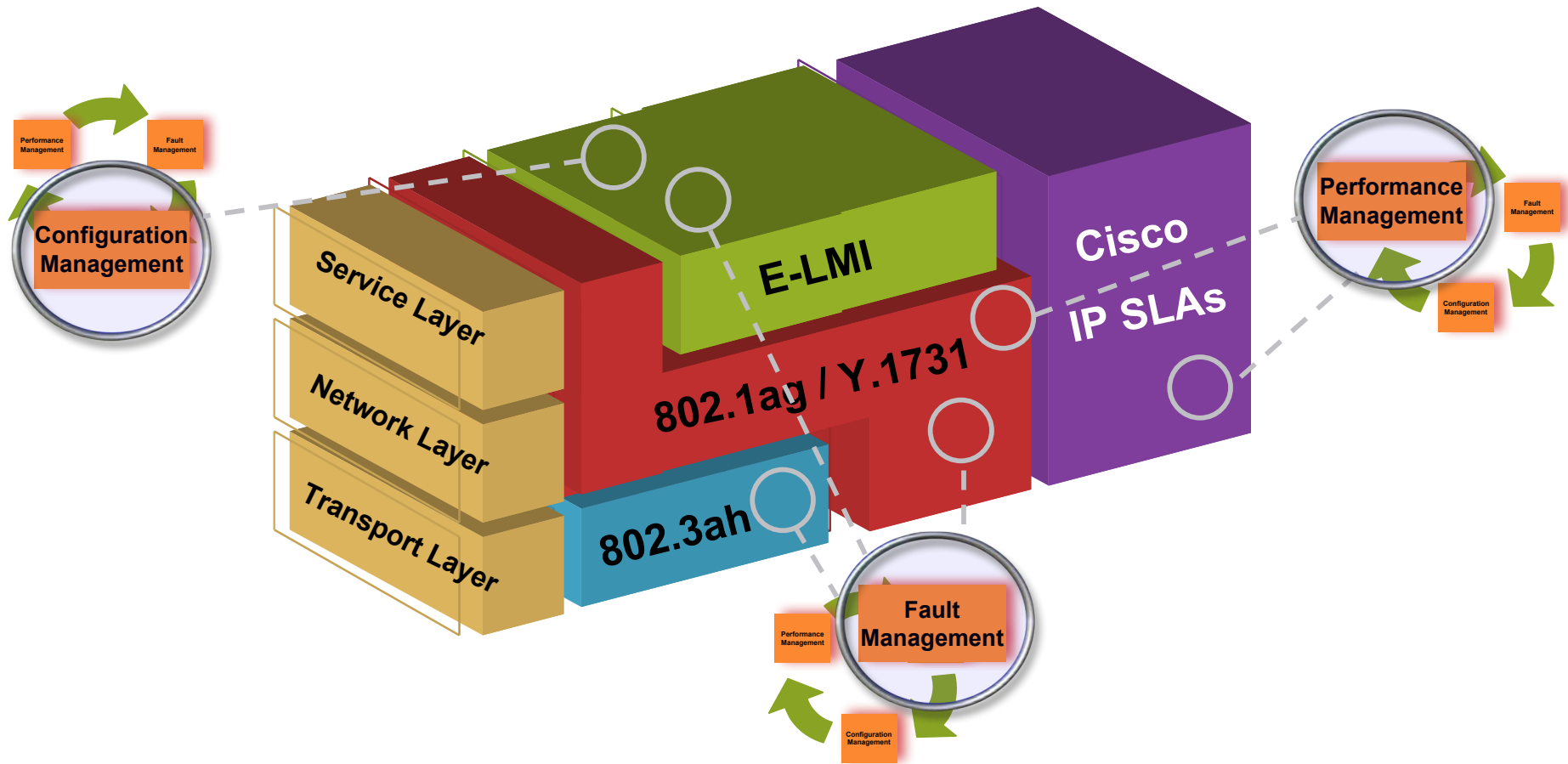
- ## ITU-T Y.1731

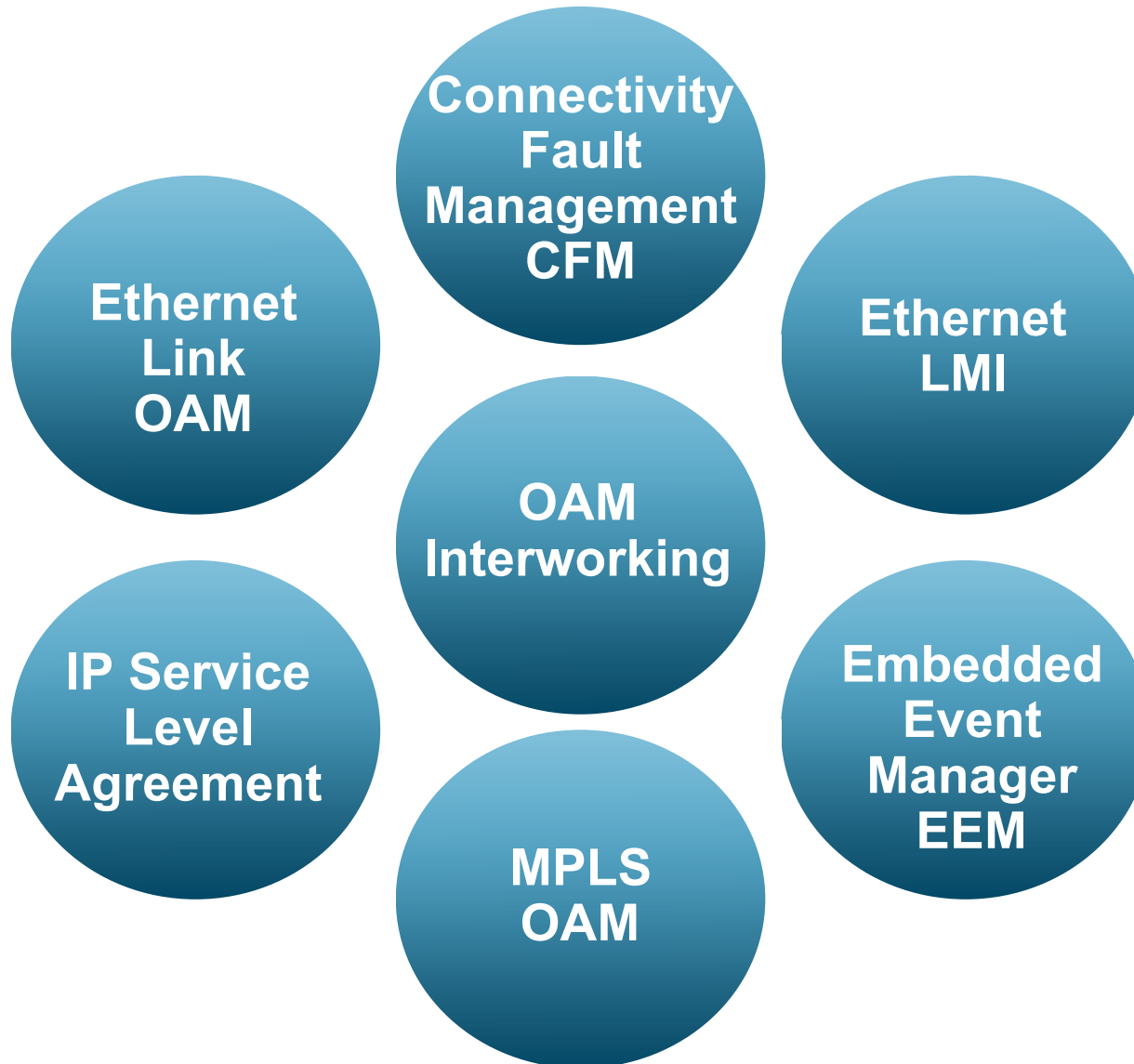 OAM functions and mechanisms for Ethernet-based networks

- ## MEF E-LMI

  Ethernet Local Management Interface
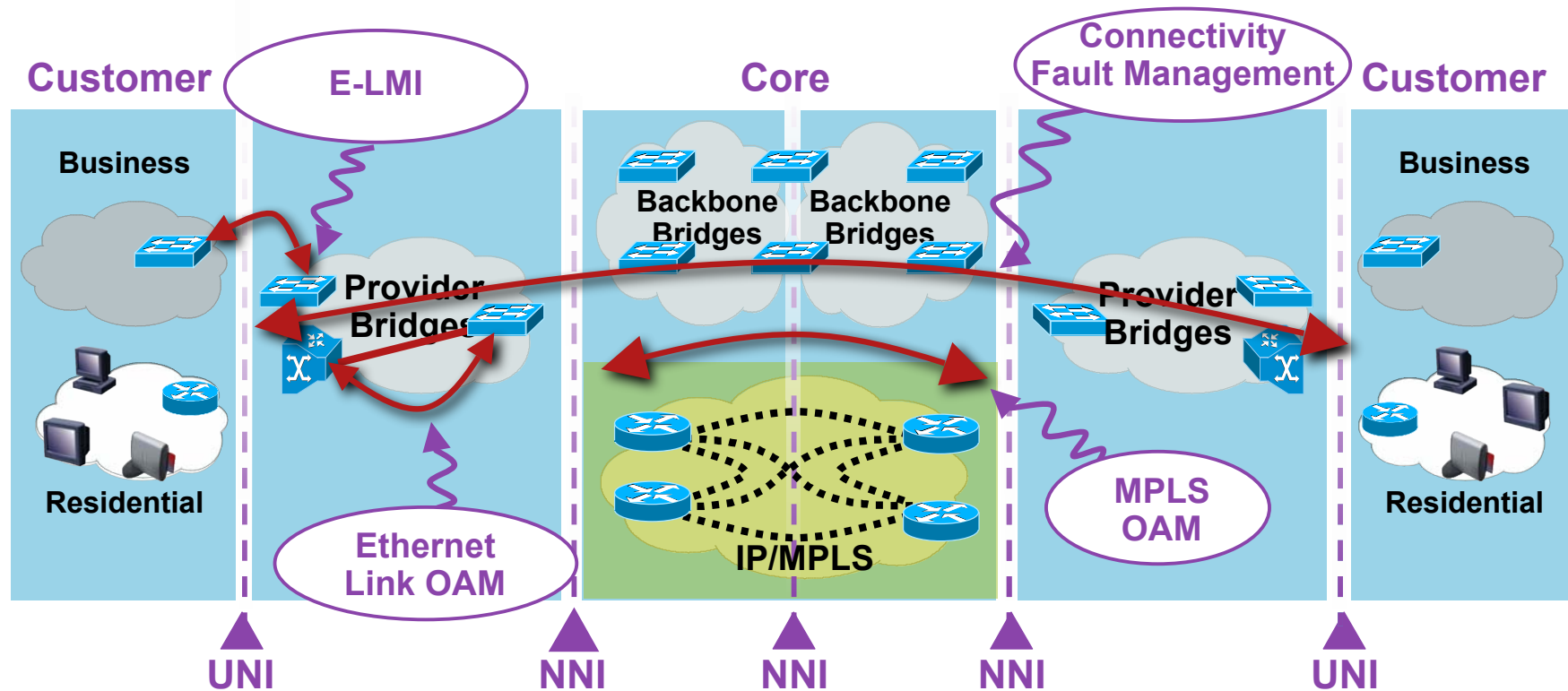
Ethernet OAM
Building Blocks

Service Layer

Network Layer

Transport Layer

E-LMI

802.1ag / Y.1731

Cisco IP SLAs

802.3ah

Configuration Management
- Performance Management
- Fault Management

Performance Management
- Fault Management
- Configuration Management

Fault Management
- Performance Management
- Configuration Management

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 Carrier Ethernet OAM
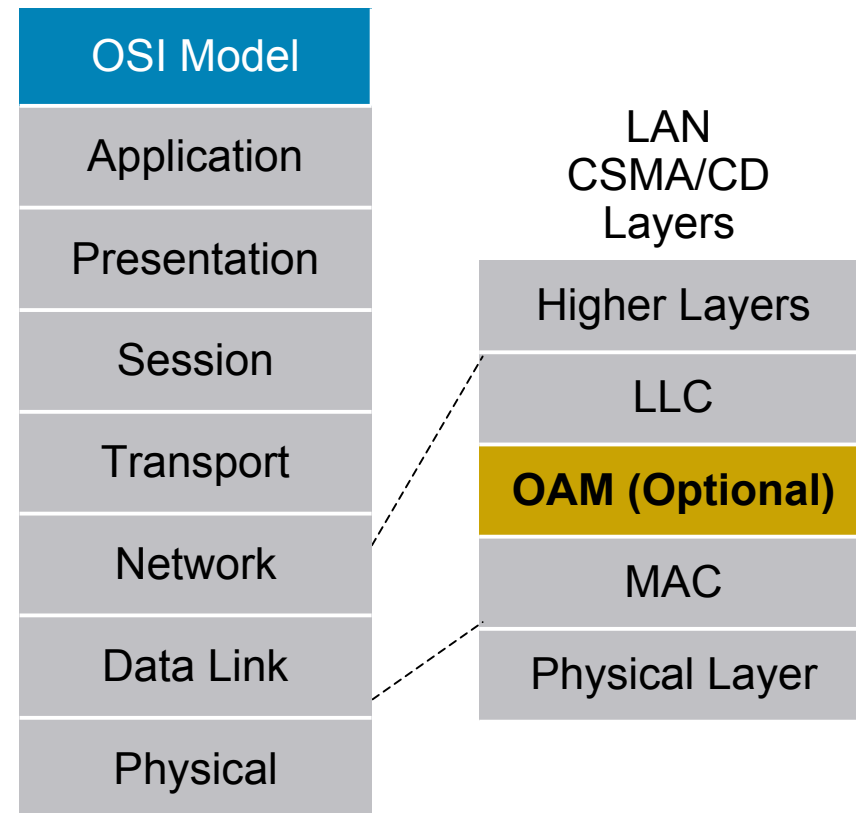## Protocol Positioning

- 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)

 Cisco Public

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"[1] frames called OAMPDUs which are never forwarded by MAC clients

- Standardized: IEEE 802.3ah, clause 57 (now in IEEE 802.3-2005)

OSI Model
Application
Presentation
Session
Transport
Network
Data Link
Physical

LAN
CSMA/CD
Layers

Higher Layers
LLC
OAM (Optional)
MAC
Physical Layer

(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

Master OAM

Slave OAM
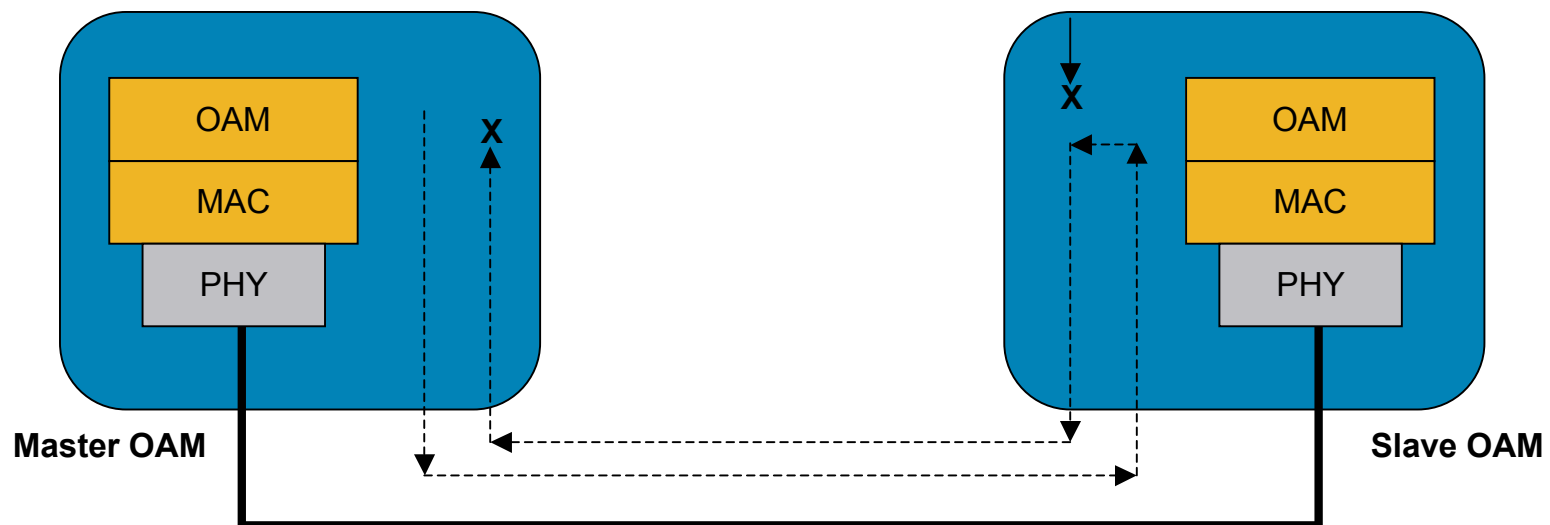
Connectivity Fault Management (CFM)

IEEE 802.1ag

 Cisco Public

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 (Cont.)

- Key CFM mechanisms include:

  Nested Maintenance Domains (MDs) that break up the responsibilities for network administration of a given end-to-end service
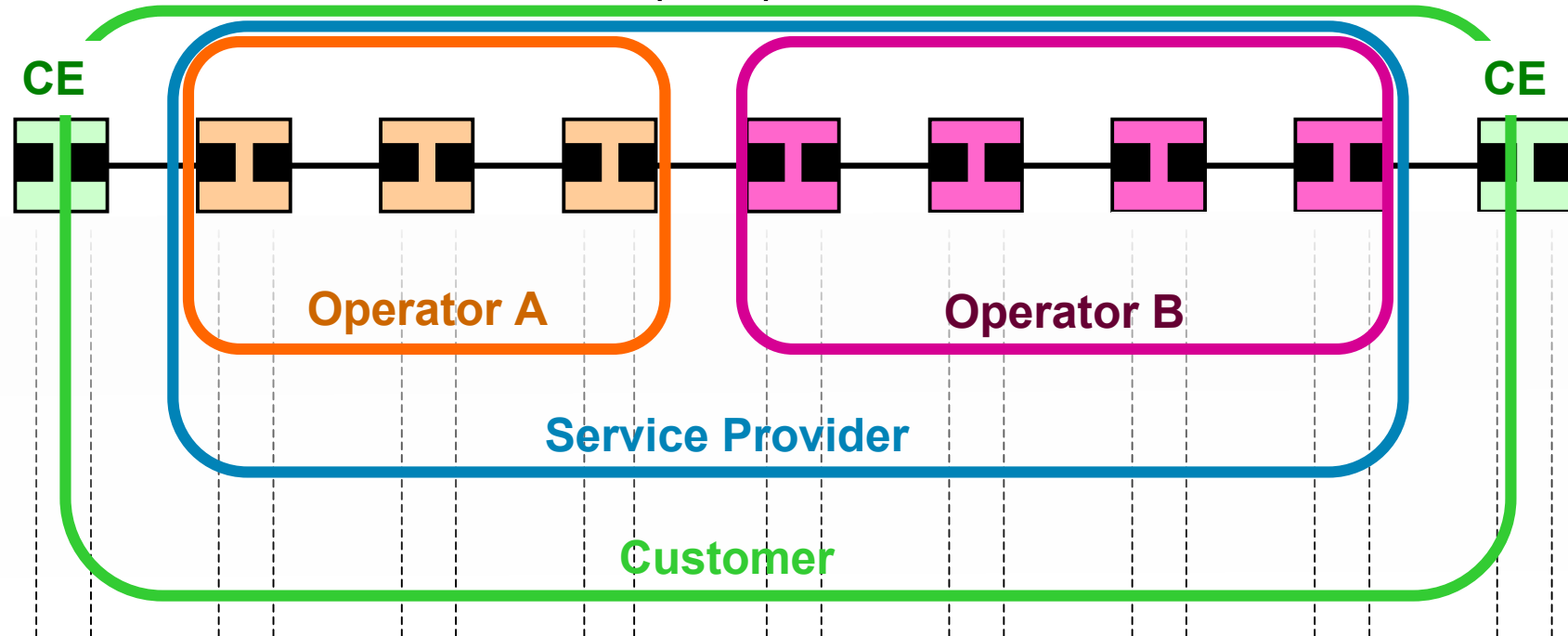
  Maintenance Associations (MAs) that monitor service instances under a given MD

  Maintenance Points (MPs) that generate and respond to CFM PDUs

  Protocols (Continuity Check, Loopback and Linktrace) used for Fault Management activities
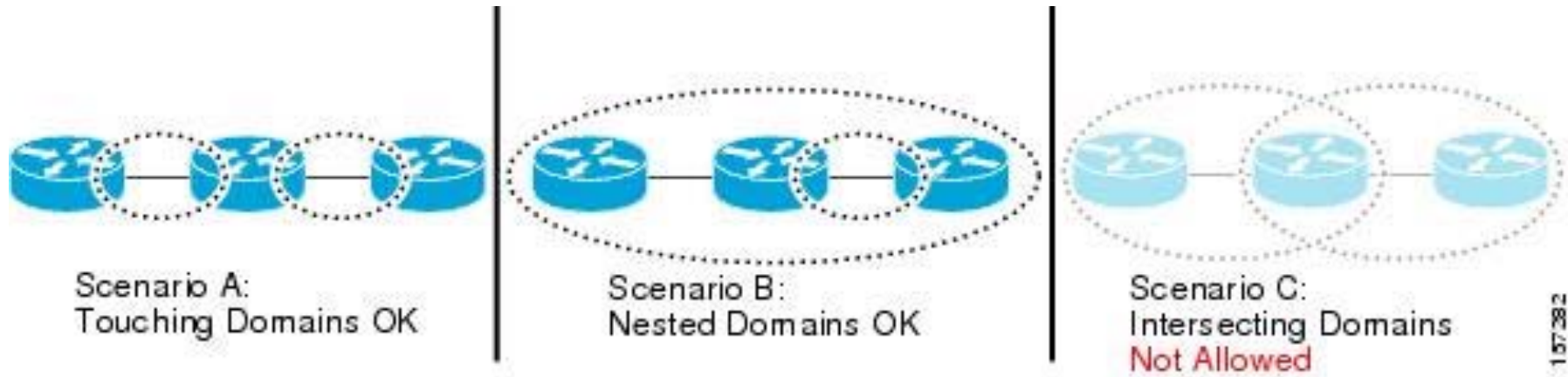
CFM Concepts
Maintenance Domain (MD)

- 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
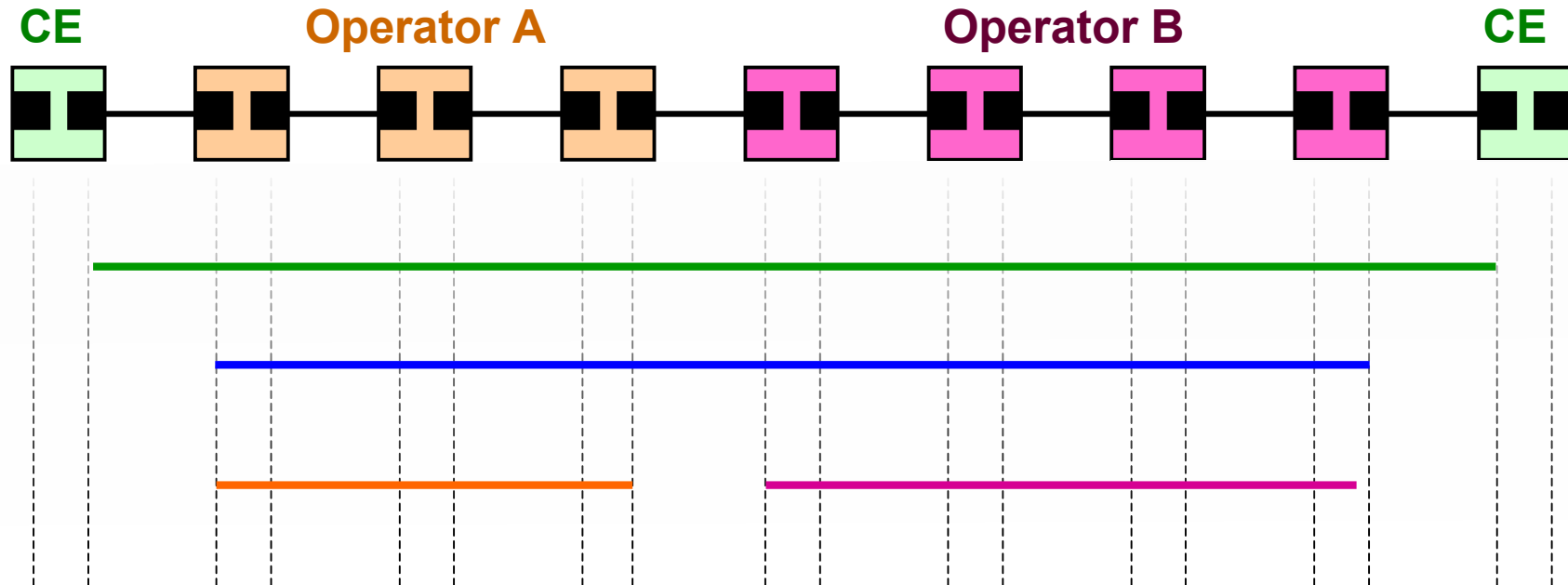- MD Name Format: null, MAC address, DNS or string-based

Maintenance Domain Nesting

Scenario A:
Touching Domains OK

Scenario B:
Nested Domains OK

Scenario C:
Intersecting Domains
Not Allowed

CFM Concepts
Maintenance Association (MA)

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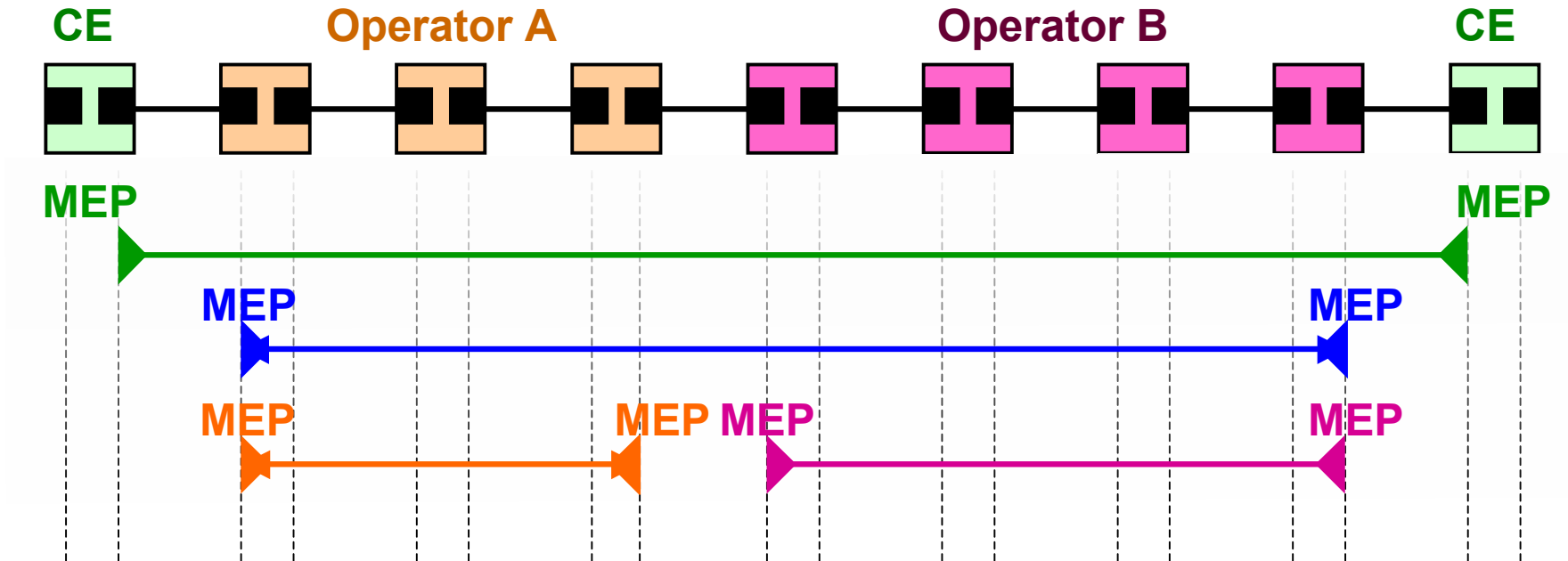
- Monitors connectivity of a particular service instance in a given MD (e.g. 1 service traversing 4 MDs = 4 MAs)
- Defined by a set of Maintenance End Points (MEP) at the edge of a domain
- Identified by MAID == "Short MA" Name + MD Name
- Short MA Name Format: Vlan-ID, VPN-ID, integer or string-based

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
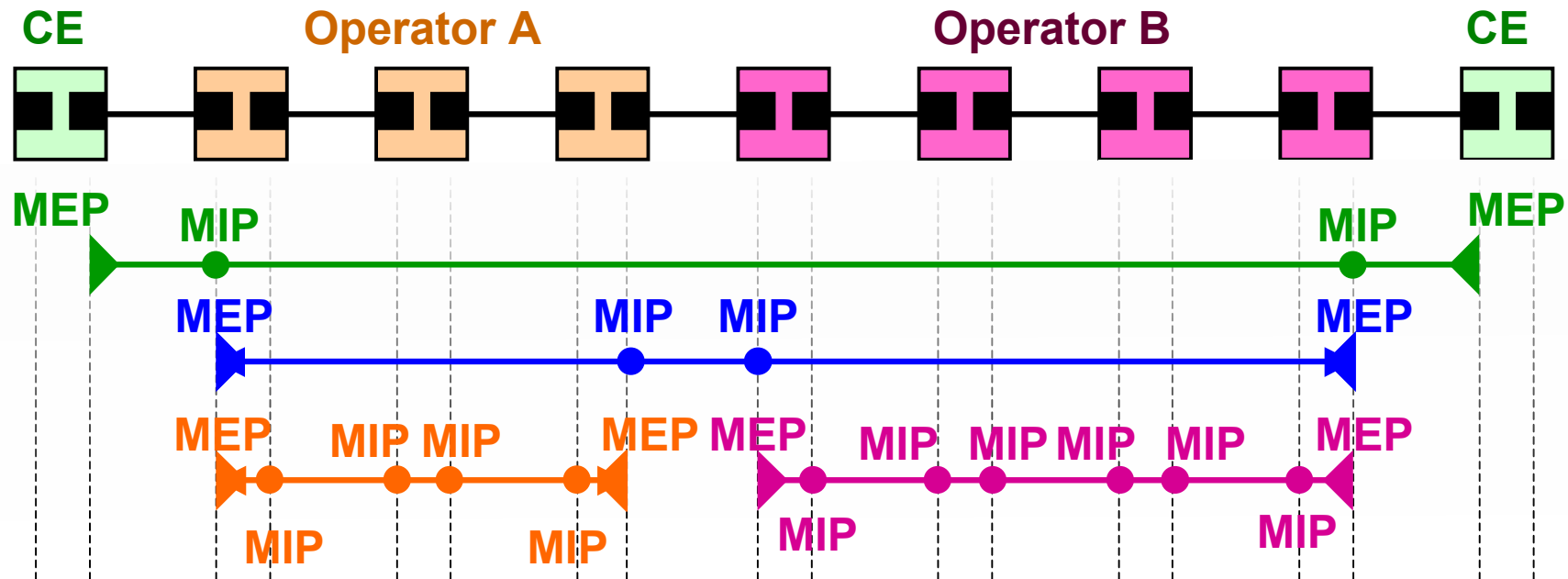
- **M**aintenance **D**omain **I**ntermediate **P**oint (MIP)
- Support the discovery of paths among MEPs and location of faults along those paths
- Can be associated per MD and VLAN / EVC (manually or automatically created)
- Can add, check and respond to received CFM PDUs

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

Bridge

Relay Entity

Port A

Port B
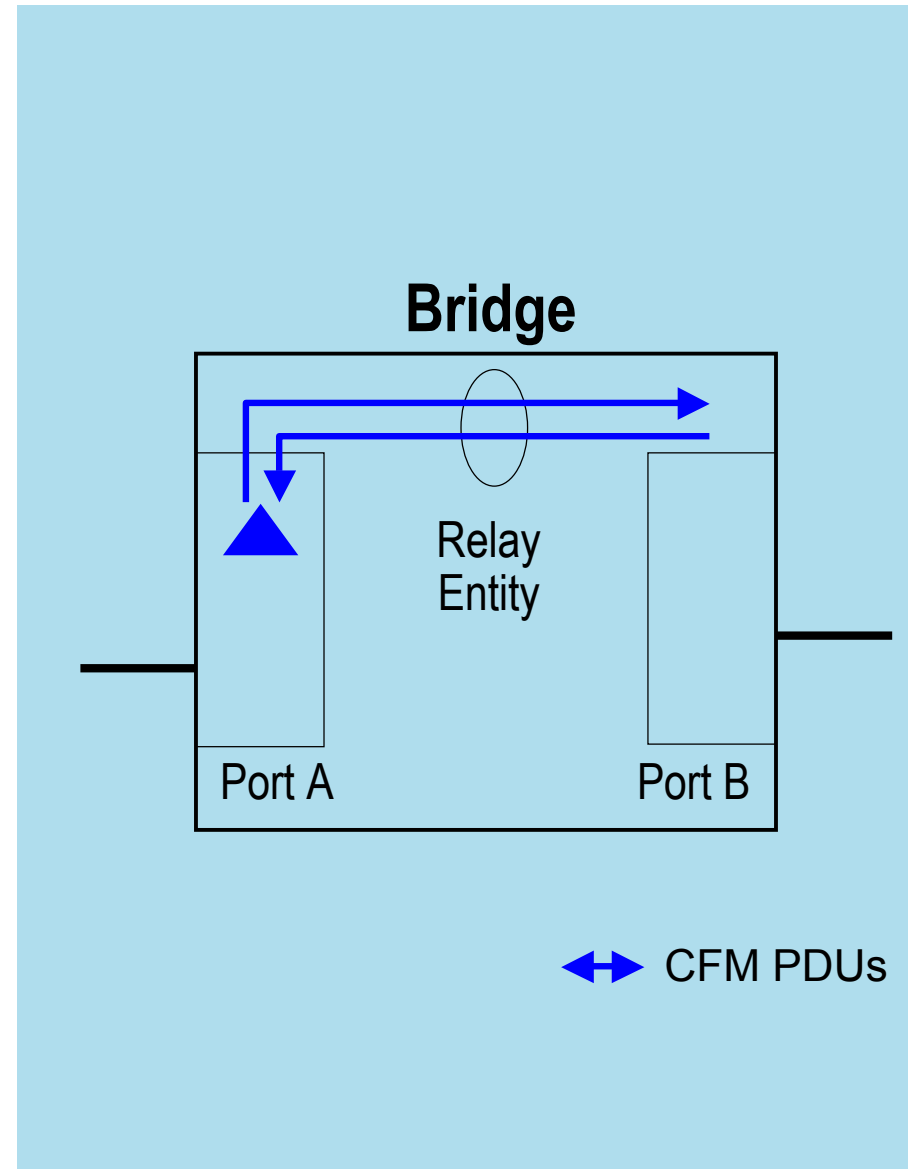
⟷ CFM PDUs

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

Bridge / Router

Relay Entity

Port A

Port B

CFM PDUs
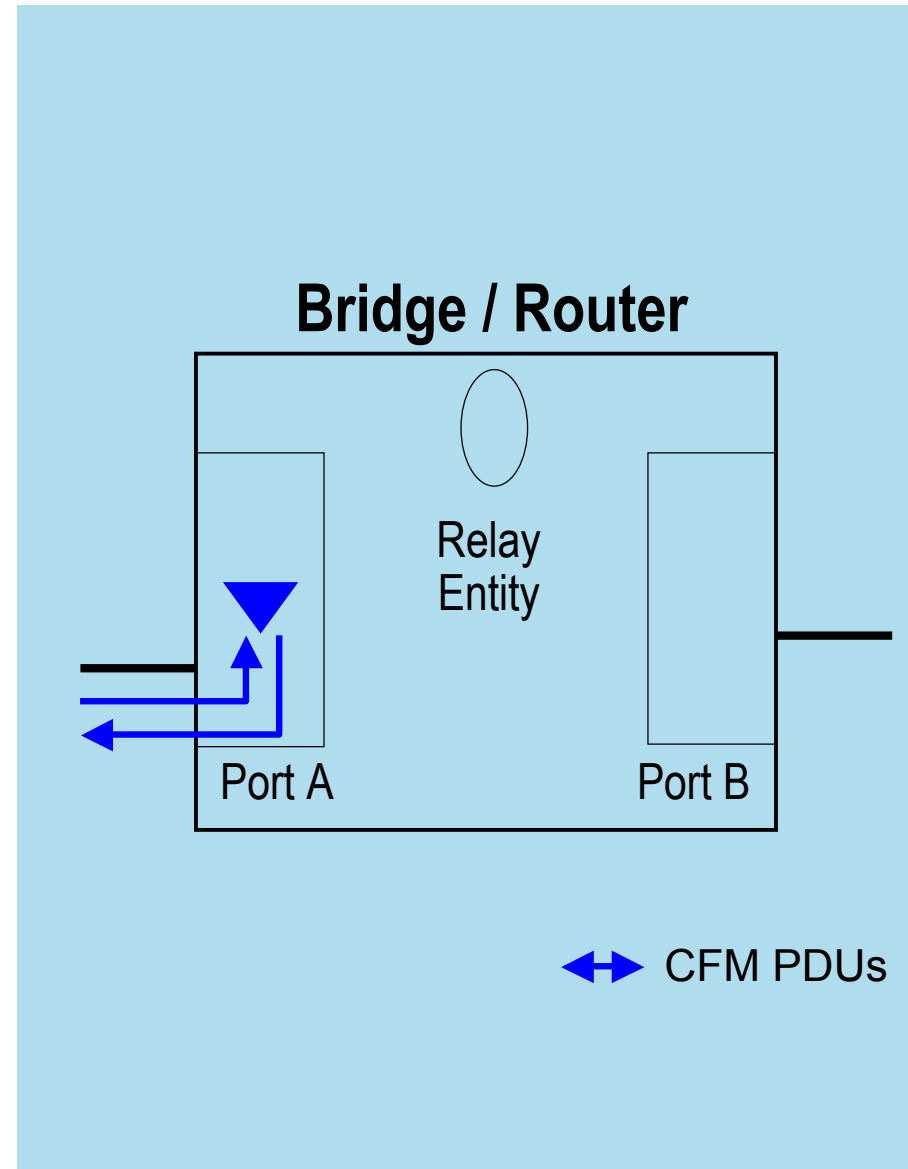
CFM Concepts
MAs and UP/DOWN MEPs

- 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

DOWN MEP to UP MEP

Bridge 1

Bridge 2

Bridge Port

Bridge Port

Relay Entity

Bridge Port

Bridge Port

Relay Entity

Monitored area

UP MEP to UP MEP

Bridge 1

Bridge 2

Bridge Port

Bridge Port

Relay Entity

Bridge Port

Bridge Port

Relay Entity

Monitored area
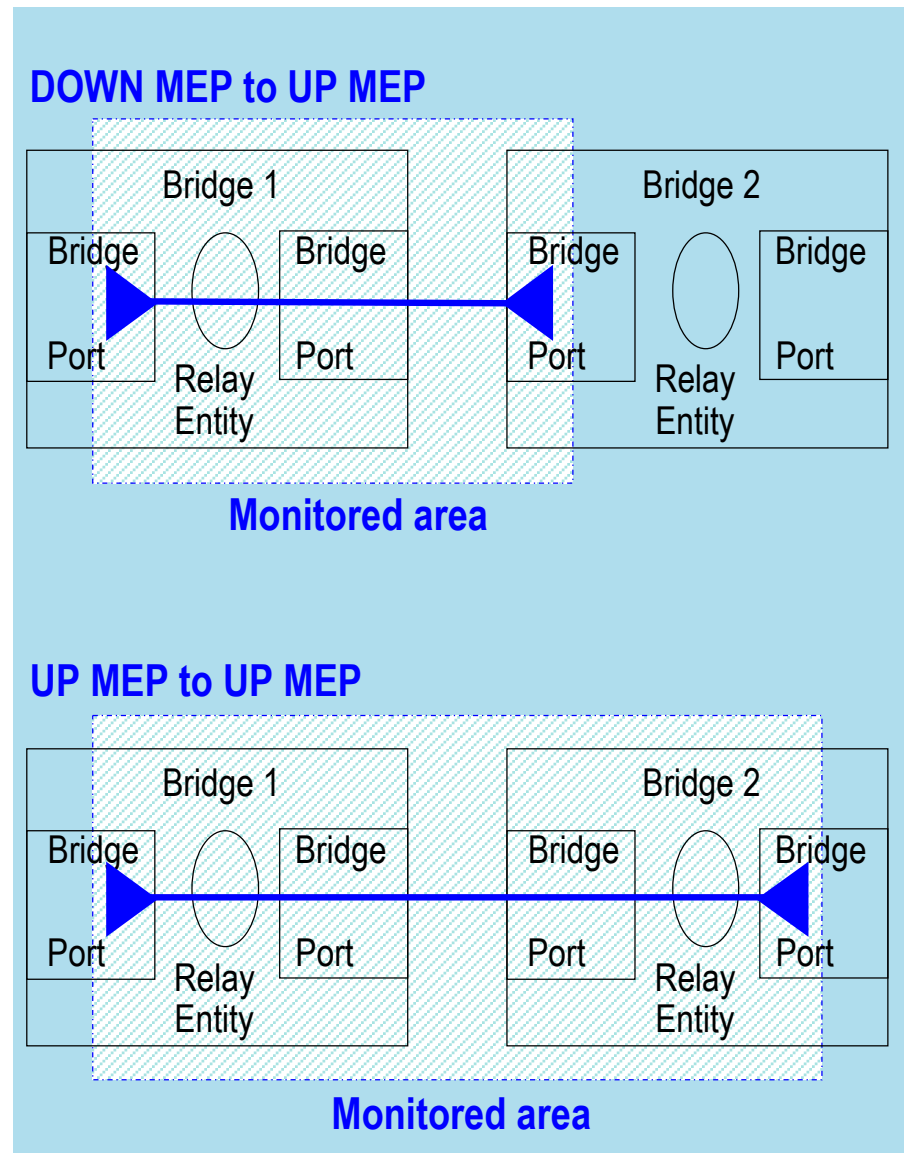
CFM Protocols

- 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

CE **Operator A** **Operator B** **CE**

Catalogue **Catalogue** **Catalogue and Terminate**

MEP **MIP** **MIP** **MEP**

① ② ③

Ⓧ **Continuity Check Message (CCM)**
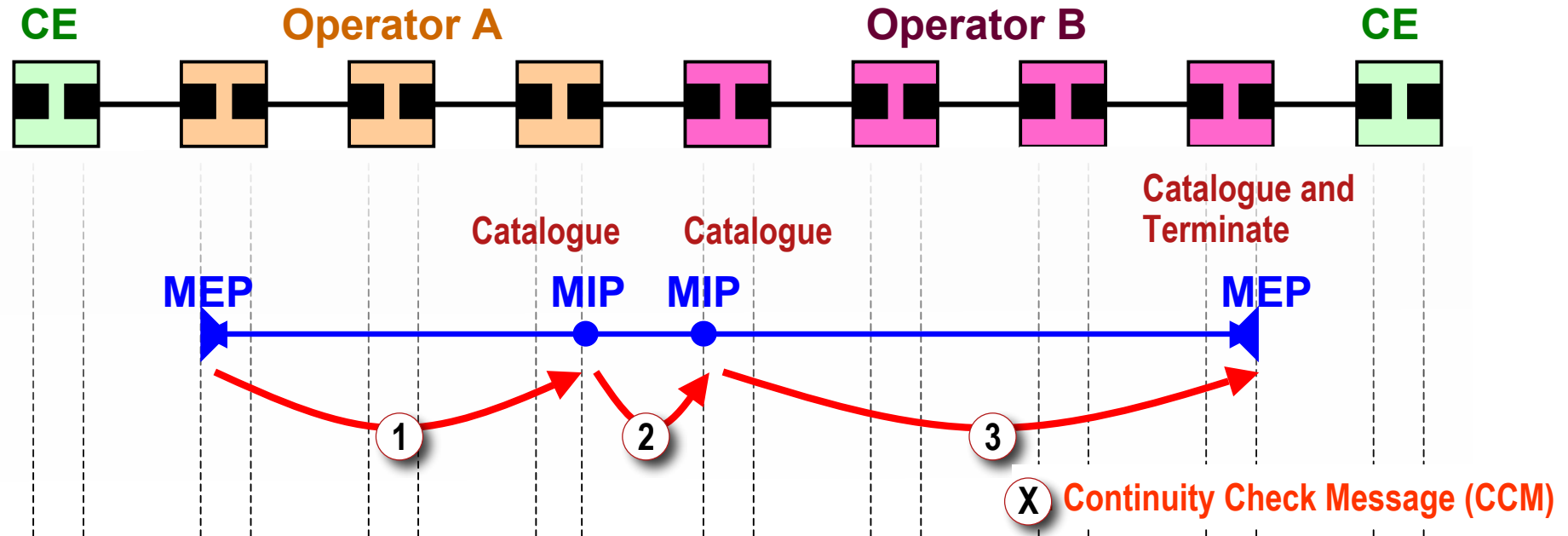
- Used for Fault Detection and Notification

- 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

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

CFM Protocols
Loopback Protocol
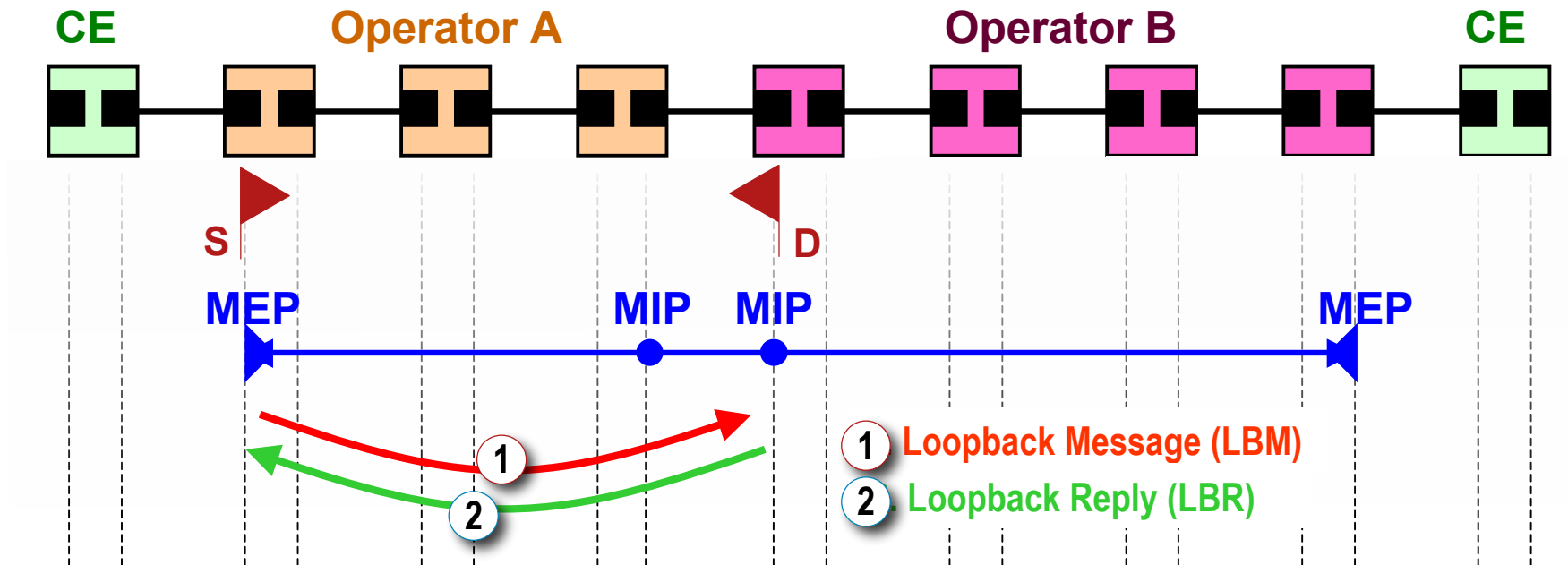
- Used for Fault Verification──Ethernet Ping

- 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

CE   Operator A   Operator B   CE

S   D
MEP   MIP   MIP   MEP

6
4
2

1
3
5

X 1, 3, 5 Linktrace Message (LTM)
Y 2, 4, 6 Linktrace Reply (LTR)
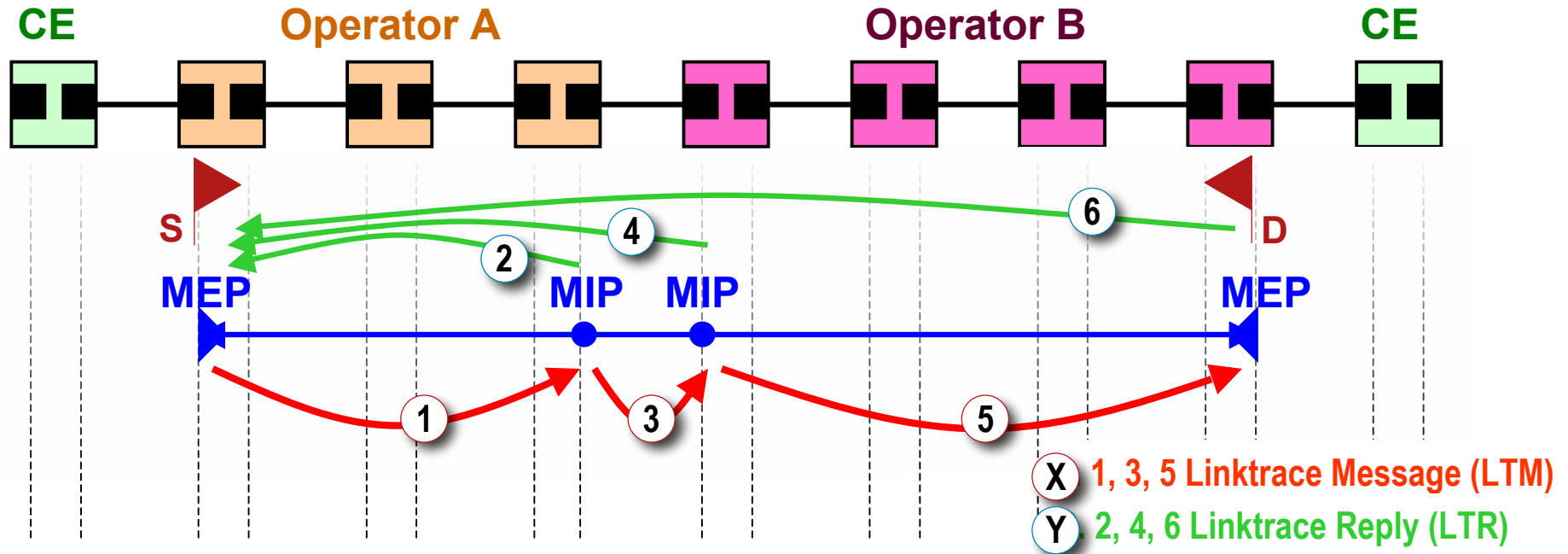
- Used for Path Discovery and Fault Isolation—Ethernet Traceroute

- 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

- Run Connectivity Check to proactively detect a soft or hard failure

- Upon a failure detection, use Loopback to verify it

- Upon verification, run Traceroute to isolate it; multiple segment LPs can also be used to isolate the fault

- 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

CFM Deployment
Scenario A

CE1   Access 1   Aggregation 1   Aggregation 2   Access 2   CE2

Admin Domain "A"

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

CFM Deployment
Scenario A (Cont.)

CE1　Access 1　Aggregation 1　Aggregation 2　Access 2　CE2

Ethernet Aggregation

Customer Domain

End to End Customer service monitoring (optional)

SP Domain

End to End SP service monitoring

Link Domain

Port MEPs
First mile link monitoring

▷ MEP   ◯ MIP

CFM Deployment
Scenario B

CE1   Access 1   Aggregation 1   Aggregation 2   Access 2   CE2

Ethernet Aggregation

Admin Domain "A"   Admin Domain "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.)

CE1   Access 1   Aggregation 1   Aggregation 2   Access 2   CE2

Ethernet Aggregation

Customer Domain

End to End Customer service monitoring (optional)

Operator Domain

Independent Operator service monitoring

Link Domain

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 mip …
 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

CFM on L2 VFI

EXAMPLE:

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

```
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

CE　　Operator A　　　　　　　Operator B　　CE

MEP GE2/7　　　　MIP GE2/1

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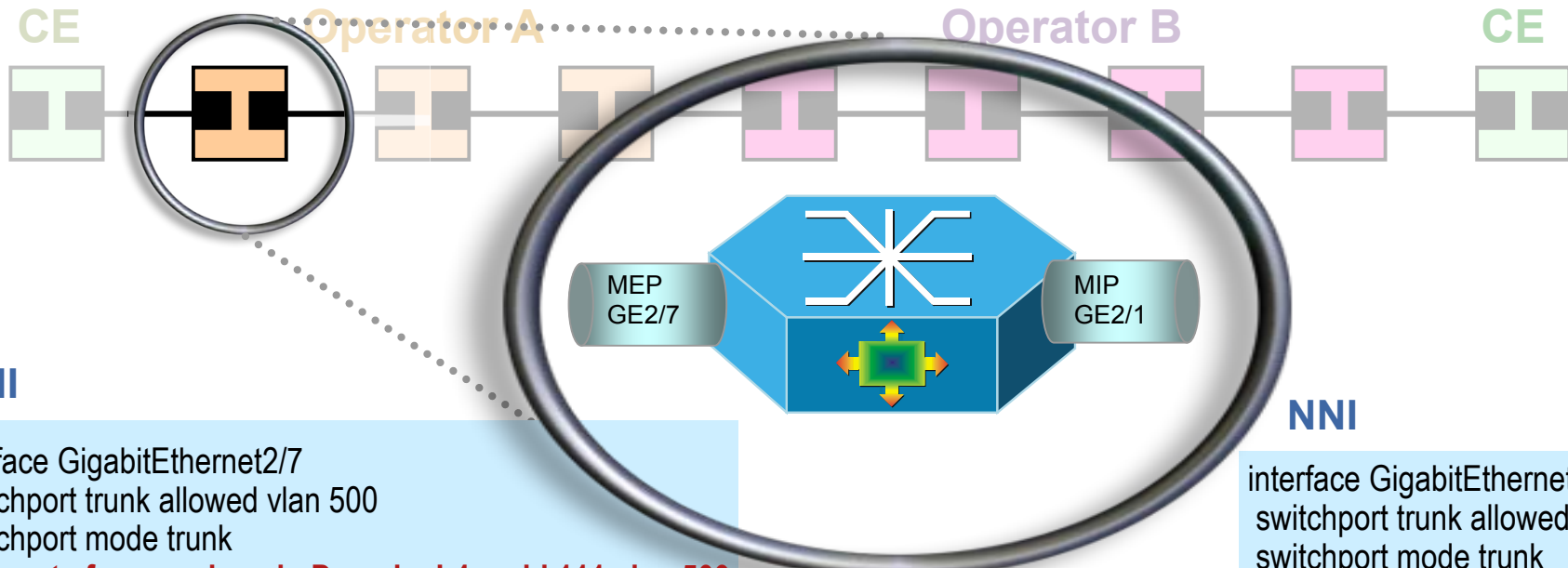
interface GigabitEthernet2/7
 switchport trunk allowed vlan 500
 switchport mode trunk
 ethernet cfm mep domain Domain_L4 mpid 111 vlan 500

MEP

NNI

interface GigabitEthernet2/1
 switchport trunk allowed vlan 500
 switchport mode trunk
 ethernet cfm mip level 4 vlan 500

Manual MIP

Global Configuration

ethernet cfm ieee
ethernet cfm global
!
ethernet cfm domain Domain_L4 level 4 - - - → **MD and MD Level**
   service customer_500_provider vlan 500 - - - → **MA**
     continuity-check
     continuity-check interval 1s
!
ethernet cfm logging alarm cisco
ethernet cfm logging alarm ieee

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

CE   **Operator A**   **Operator B**   **CE**

MIP GE2/1

MIP GE2/2
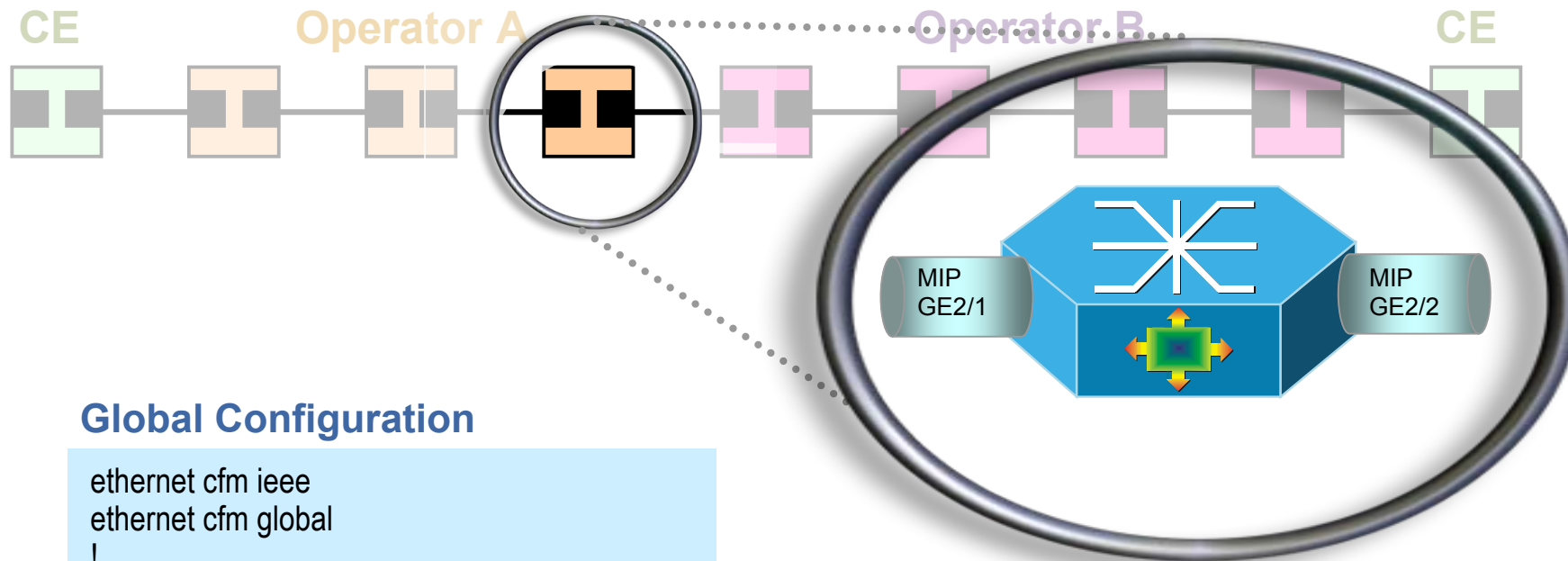
Global Configuration

```
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
```

NNI

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

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

CE   Operator A   Operator B   CE

MIP
GE3/2

MEP
GE3/1

UNI

```
interface GigabitEthernet3/1
 switchport trunk allowed vlan 500
 switchport mode trunk
 ethernet cfm mep domain Domain_L4 mpid 222 vlan 500
```

NNI
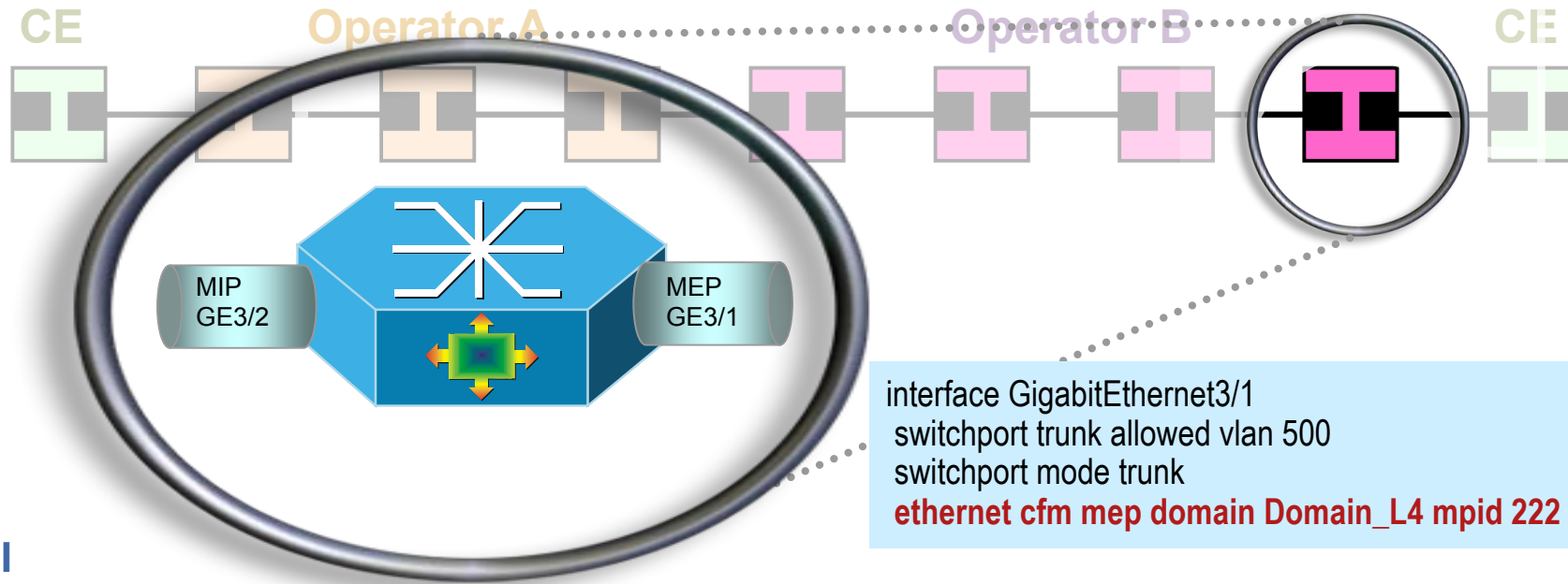
```
interface GigabitEthernet3/2
 switchport trunk allowed vlan 500
 switchport mode trunk
```

MIPs are created on all
interfaces where VLAN 500 is
allowed at level 4

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
```

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

IEEE 802.1ag		ITU-T Y.1731	
ME	Maintenance Entity	**ME**	Maintenance Entity
MA	Maintenance Association	**MEG**	ME Group
MAID	MA Identifier	**MEGID**	MEG Identifier
MD	Maintenance Domain	---	No such construct available
MD Level	MD Level	**MEG Level**	MEG Level
MEP	MA End Point	**MEP**	MEG End Point
MIP	MD Intermediate Point	**MIP**	MEG Intermediate Point
---	No such construct available	**Server MEP**	Server MEP

ITU-T Y.1731 Overview

- OAM Functions for Fault Management

  Ethernet Continuity Check (ETH-CC) (Y.1731 adds unicast CCM)

  Covered by IEEE 802.1ag

  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)

  Cisco Enhancement   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)

- Specification completed by MEF: http://www.metroethernetforum. org/PDFs/Standards/MEF16.doc

User Network Interface (UNI)

UNI-C   **UNI-N**

CE

Metro Ethernet Network

E-LMI
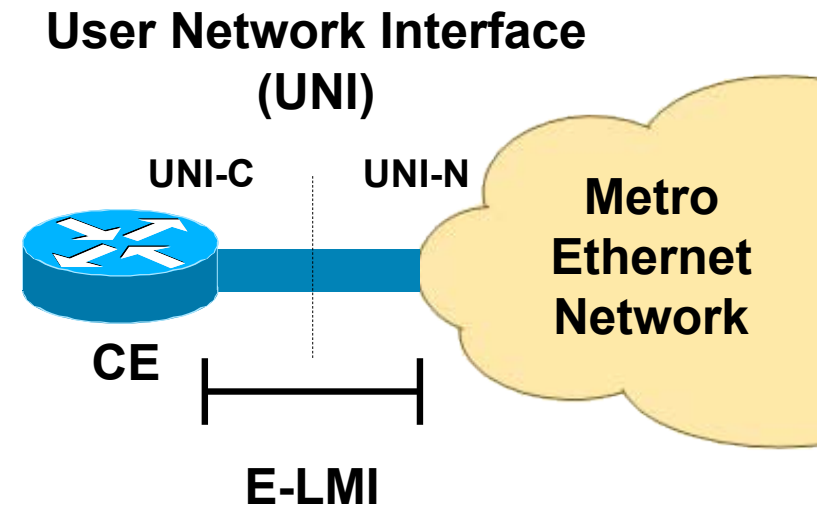
Ethernet LMI
Periodic Polling and Asynchronous Update

ELMI-CE (UNI-C)   **ELMI-PE (UNI-N)**

- 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

A → **STATUS ENQ (Ethernet LMI Check)**
B ← **STATUS (Ethernet LMI Check)** **C**

A → **STATUS ENQ (Ethernet LMI Check)**
B ← **STATUS (Ethernet LMI Check)** **C**

D **A** → **STATUS ENQ (Full Status Req)**
B ← **STATUS (Full Status Resp)** **C**

A → **STATUS ENQ (Ethernet LMI Check)**
B ← **STATUS (Ethernet LMI Check)** **C**

← **STATUS (EVC ASYNC Status)** **E**

A	T391 Expiry	**B**	Restart T391	**E**	MEN Update
C	Restart T392	**D**	N391 polls sent		
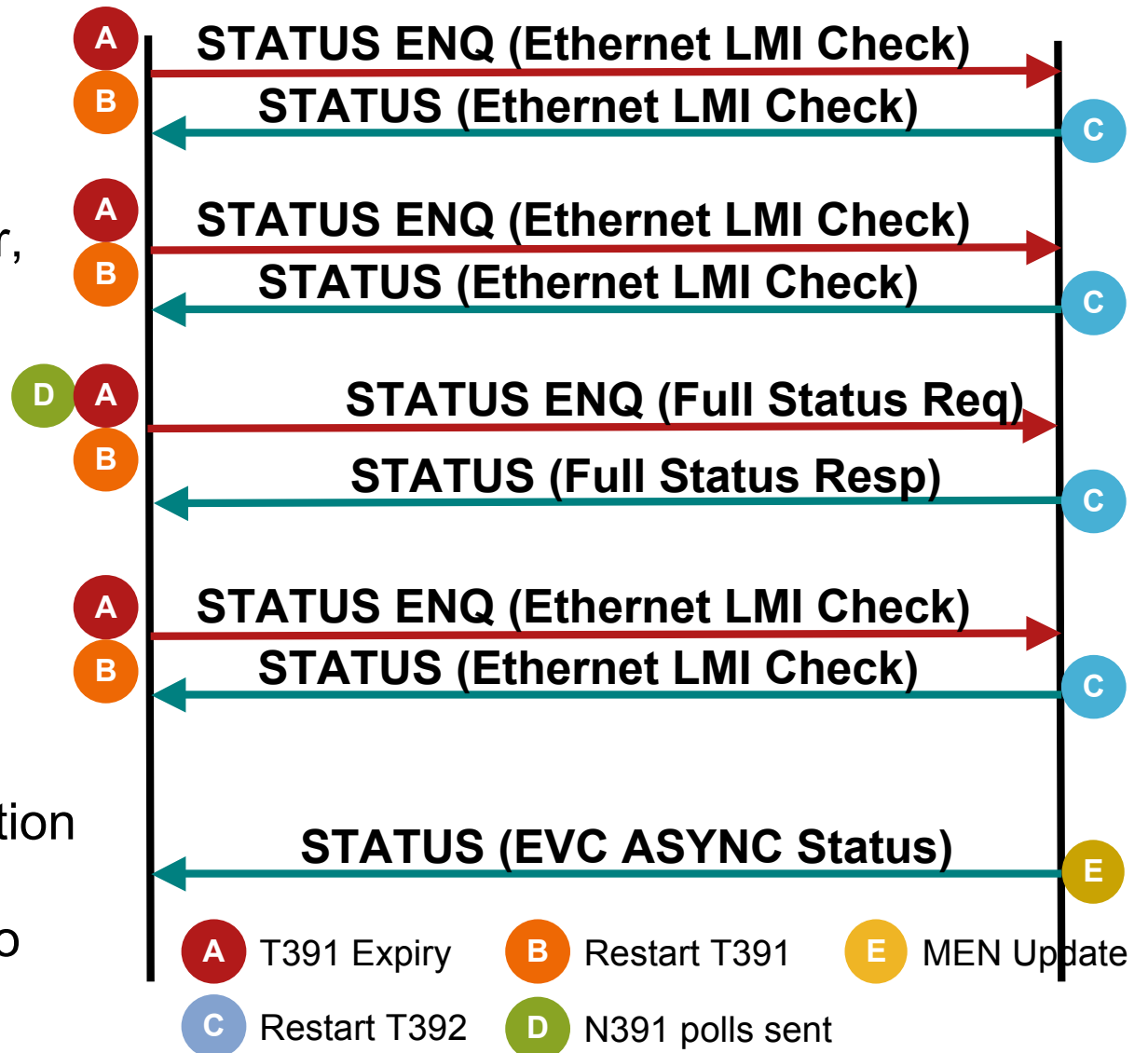
Ethernet OAM Interworking

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

Event Translation inter-domains intra-layer

Server Layers feed events into Client Layers

Service OAM

Network OAM

Network OAM

Transport OAM

Transport OAM

Transport OAM

Transport OAM
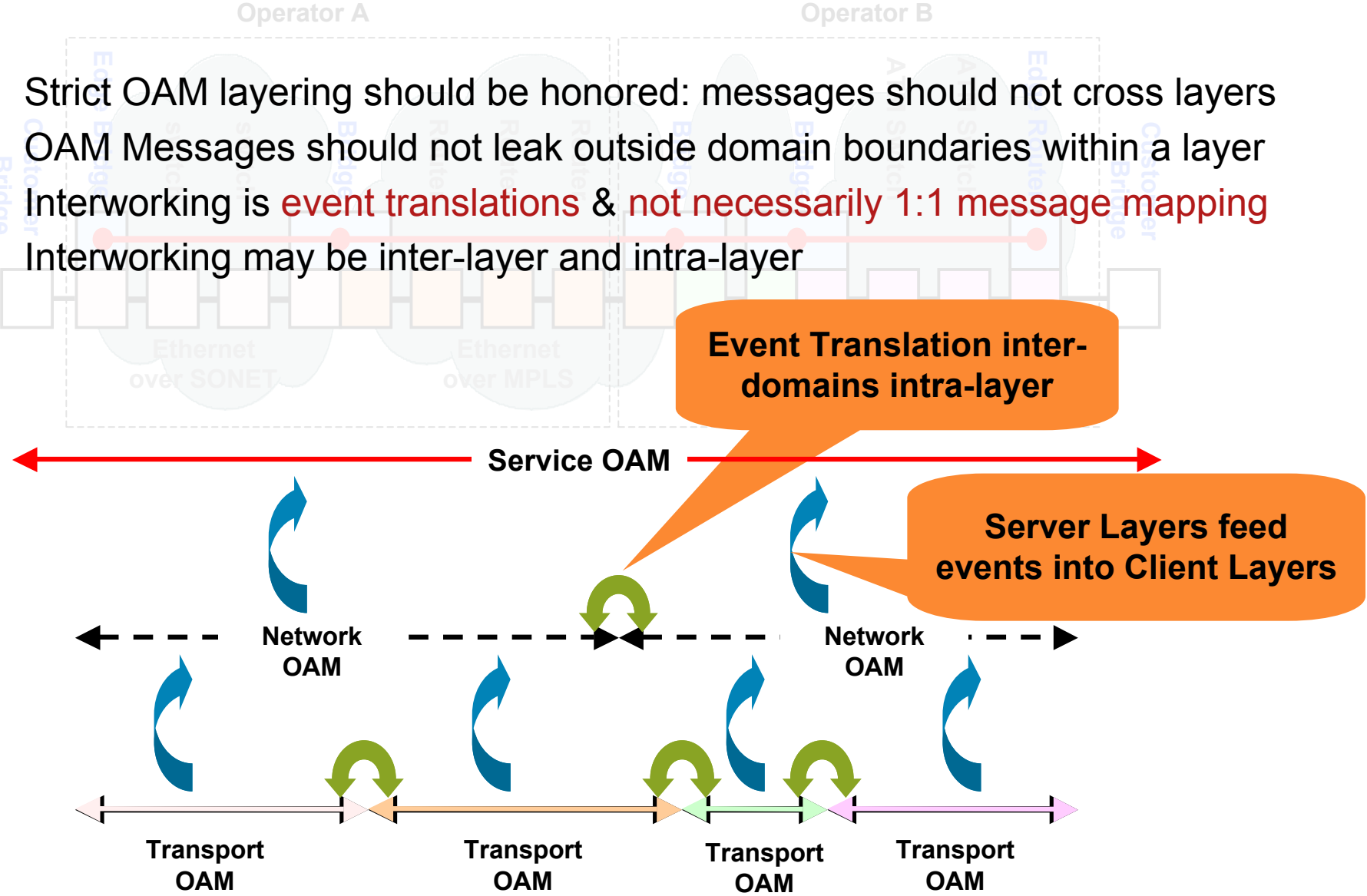
Interworking Scenarios
Main Examples Supported by Cisco IOS

CFM ➤ **E-LMI**

Link OAM ➤ **CFM**

MPLS PW OAM ➤ **E-LMI**

Interworking Scenarios
CFM to E-LMI
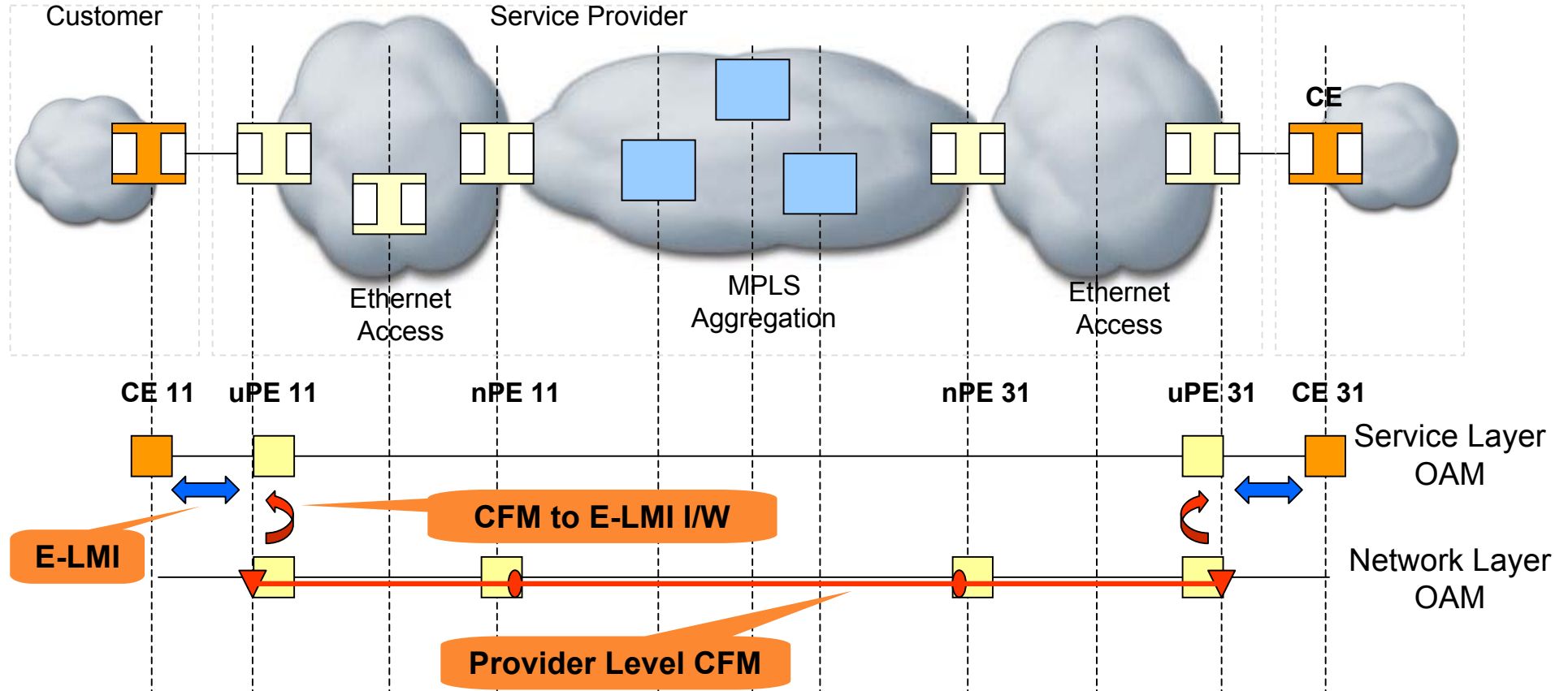
- CFM @ Provider Level acts as MEN OAM: provides EVC Status and Remote UNI Status/Name to E-LMI
  - Interface Status TLV of CC Messages carry remote UNI status
  - Cisco's Organization-specific TLV of CC Messages carry remote UNI name
  - Status of remote MEP in CCDB indicates EVC State

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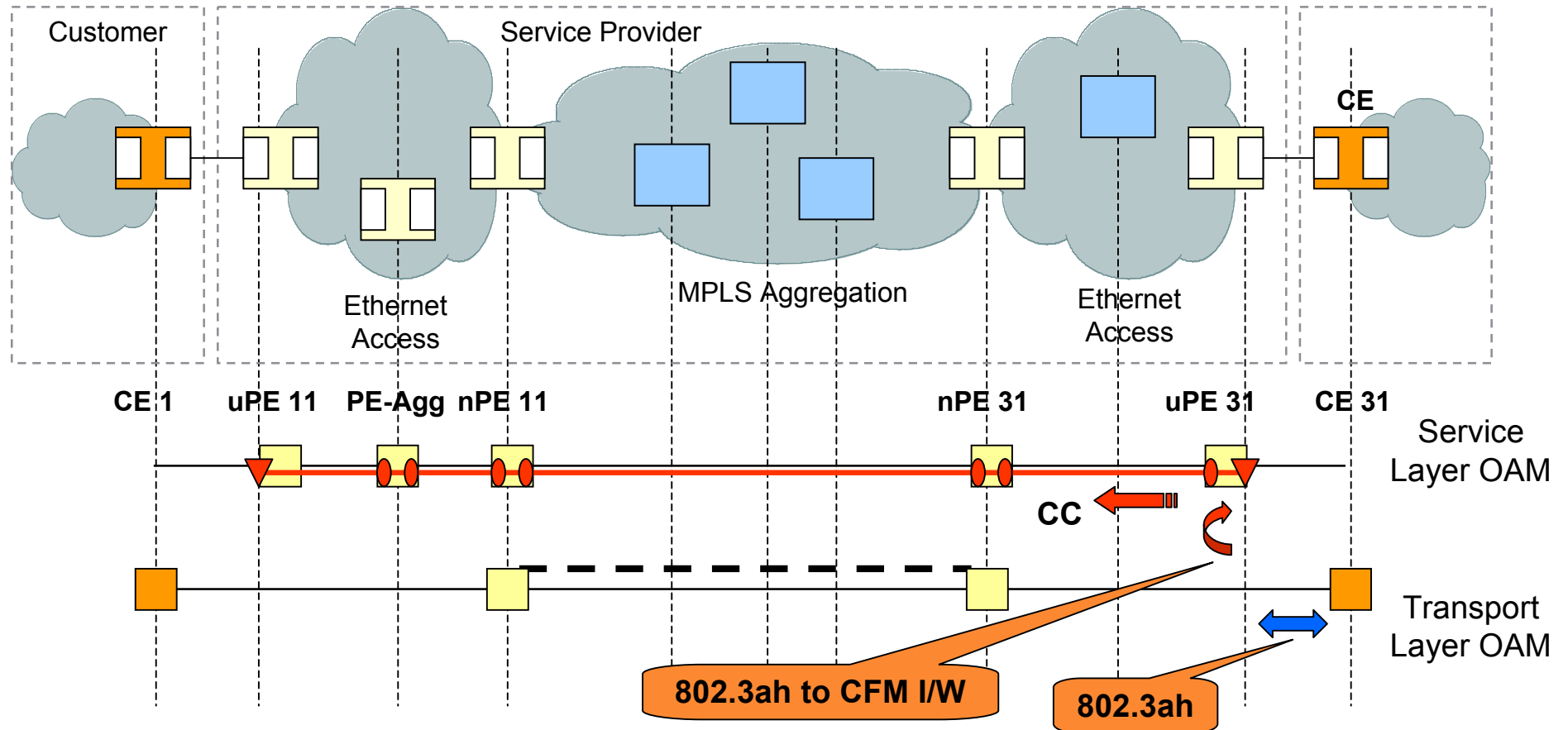
- Link Layer Defects detected by 802.3ah, relayed to CFM on same device
- CFM notifies remote devices of localized fault
- Two variants:
    CC based (802.3ah on edge of domain)
    AIS based (802.3ah within domain)

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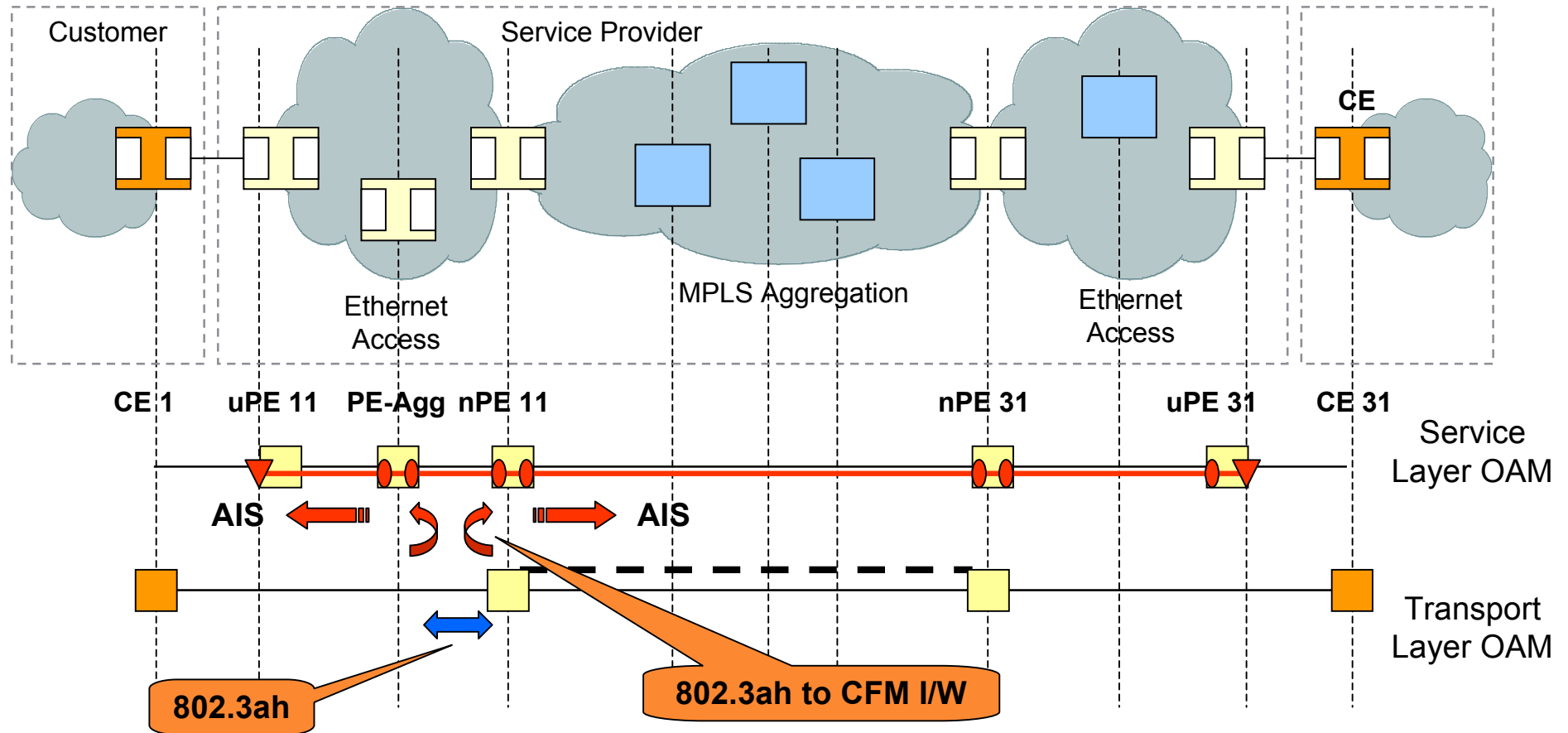
- Link Layer Defects detected by 802.3ah, relayed to CFM on same device
- CFM notifies remote devices of localized fault
- Two variants:

  CC based (802.3ah on edge of domain)

  AIS based (802.3ah within domain)

Interworking Scenarios
MPLS PW OAM to E-LMI
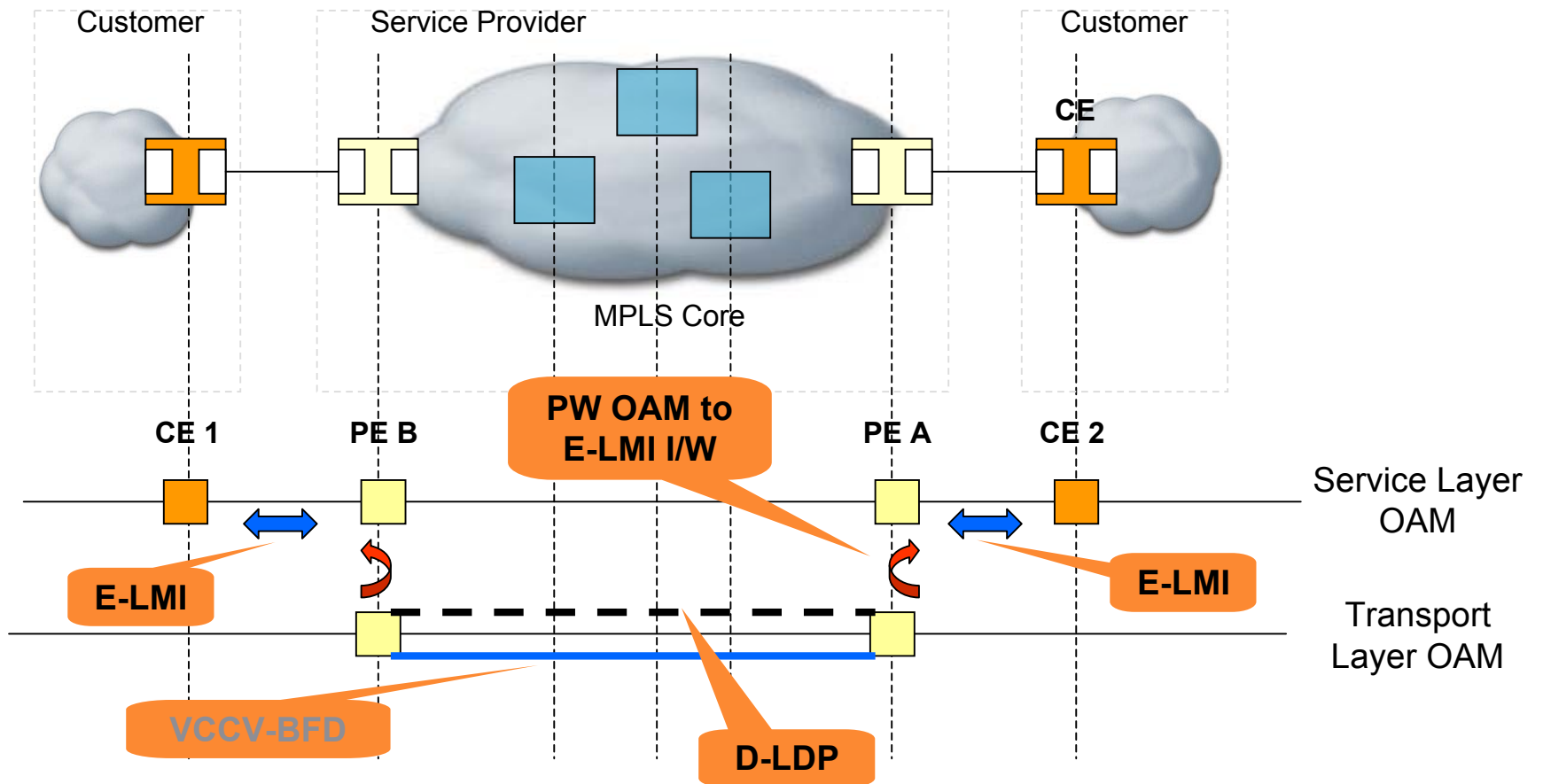
- Directed-LDP & VCCV (BFD mode) running between PEs
- D-LDP for defect notification, VCCV for defect detection
- Defects detected/communicated by PW OAM are relayed to E-LMI via I/W function on PE

Fault Management Scenarios

Cisco Public

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE   Access   Aggregation   Aggregation   Access   CE

Point-to-Point Ethernet Service

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE   Access   Aggregation   Aggregation   Access   CE

E-LMI
Link OAM

CFM

E-LMI
Link OAM

CFM
to E-LMI IW

CFM
to E-LMI IW

Link OAM
to CFM IW

Link OAM
to CFM IW

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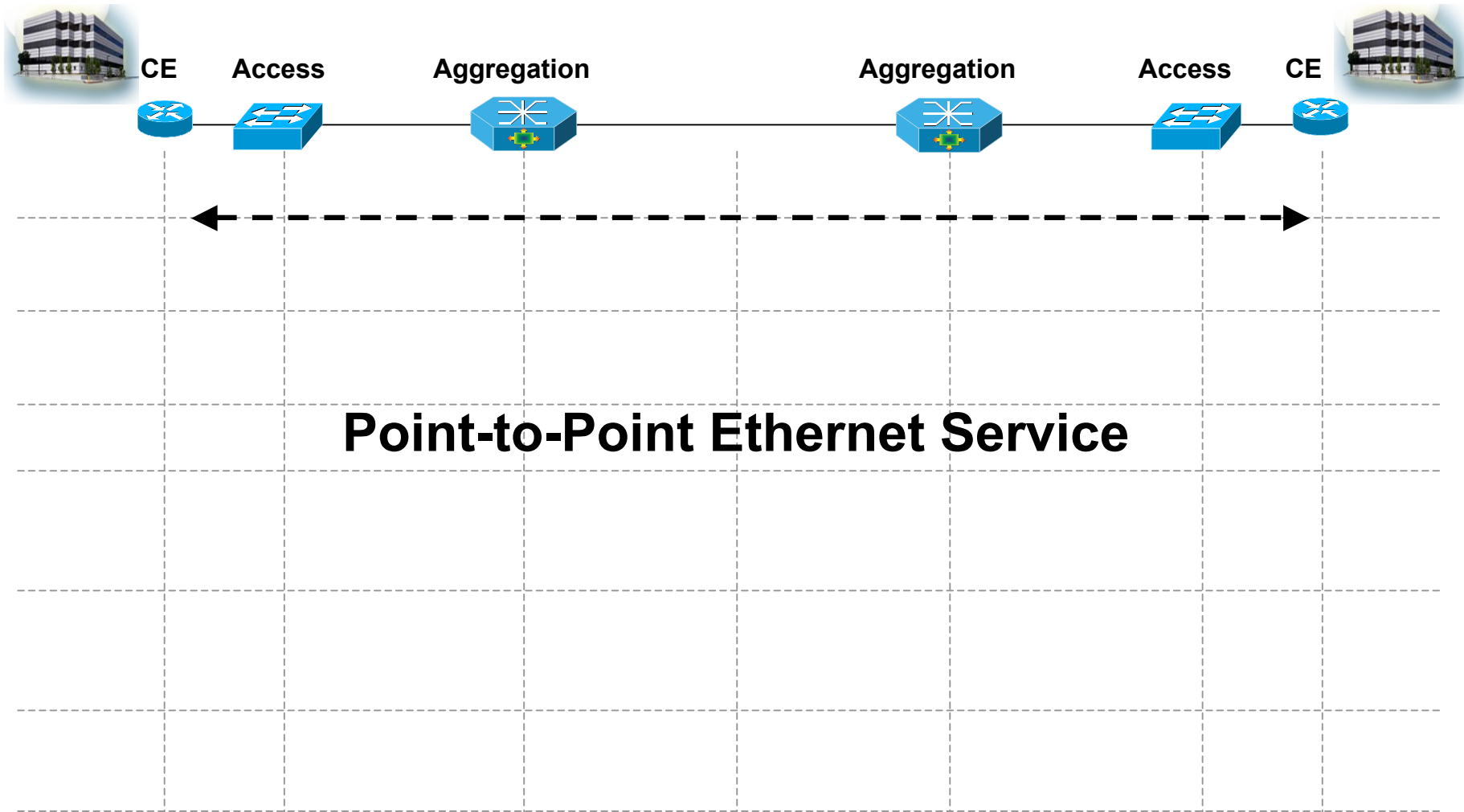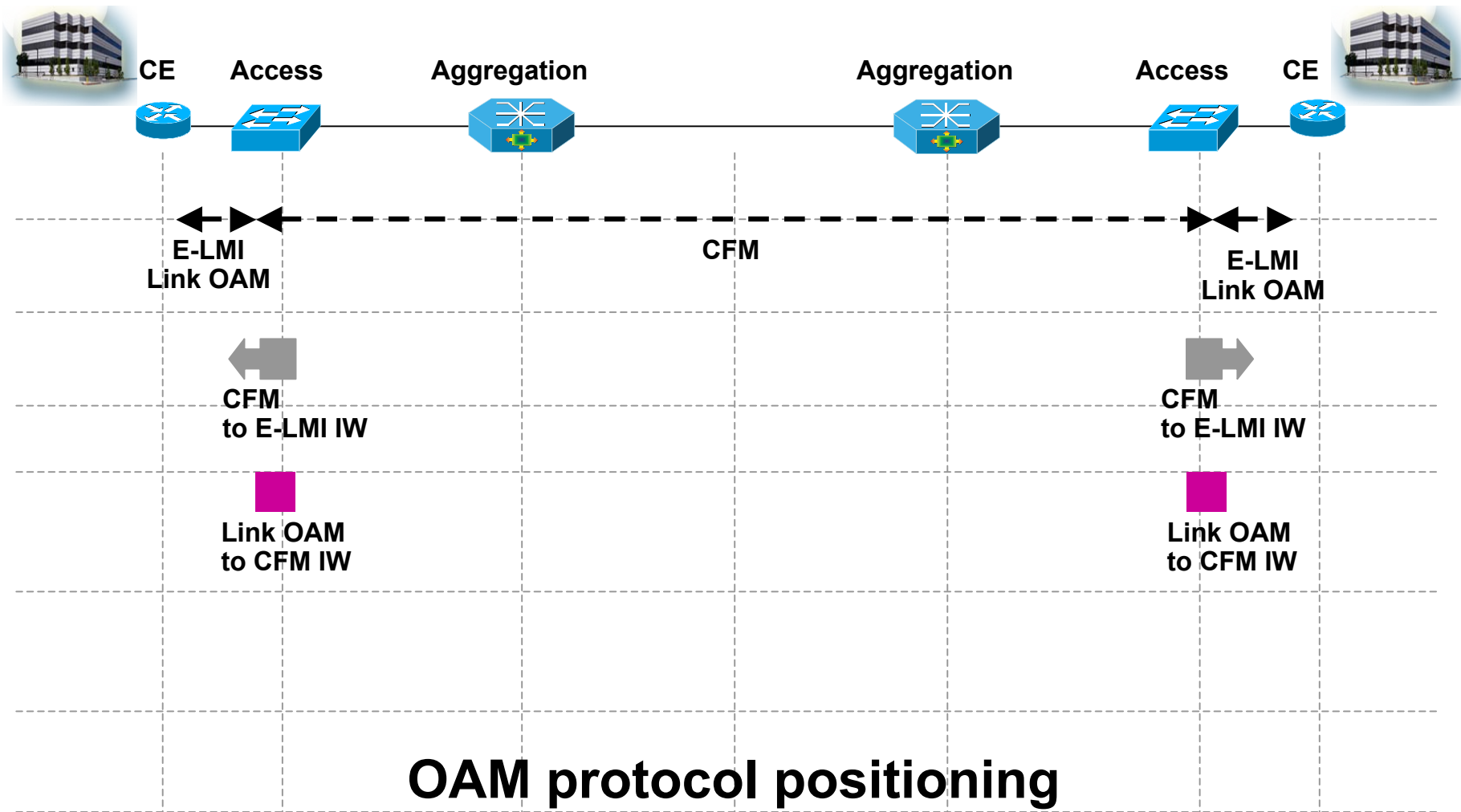
Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Proactive End-to-End Service Monitoring

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

CFM Continuity Check Messages (CCM)

t_0
t_1
t_2
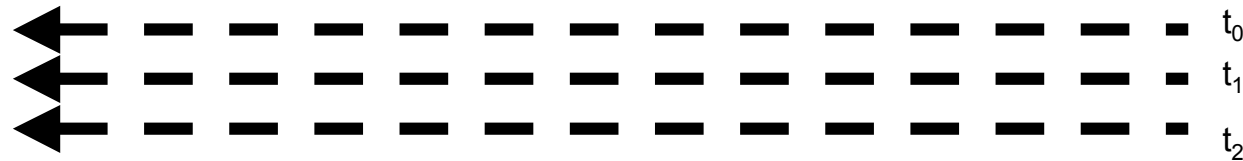
CCM
Database

```
UPE11#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------
MPID  Domain Name                          MacAddress        IfSt  PtSt
 Lvl  Domain ID                            Ingress
 RDI  MA Name                              Type Id           SrvcInst
     EVC Name                                         Age
-------------------------------------------------------------------------------
3100  PROVIDER_DOMAIN                      aabb.cc00.0599    Up    Up
 4    PROVIDER_DOMAIN                      Et0/1.100
 -    customer_100_provider                Vlan 100          N/A
      N/A                                            0s

Total Remote MEPs: 1
```

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

End-to-end Service/Failure Verification

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

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

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

uPE11# traceroute ethernet
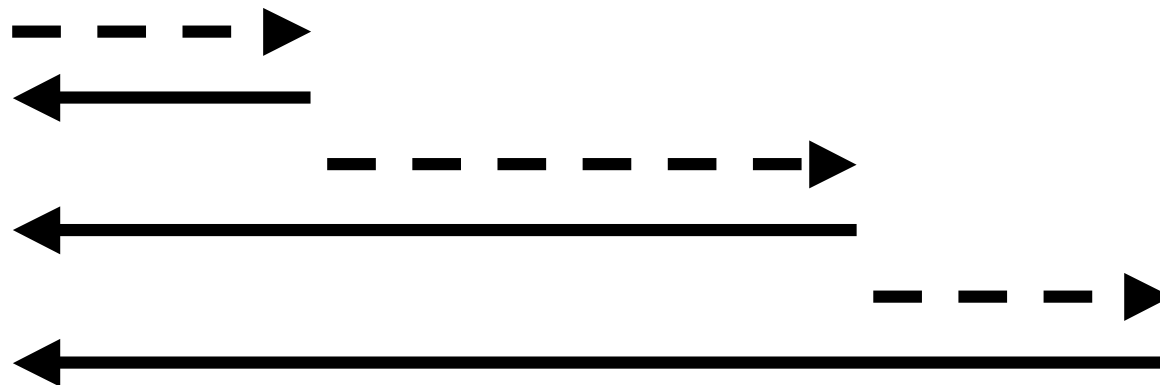
CFM Linktrace Message (LTM)
CFM Linktrace Reply (LTR)

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Service Path Discovery/Failure Isolation

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

uPE11# traceroute ethernet

```
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

B = Intermediary Bridge
! = Target Destination
* = Per hop Timeout
------------------------------------------------------------------------------
                       MAC       Ingress      Ingr Action  Relay
Action
  Hops  Host          Forwarded  Egress       Egr Action   Previous
Hop
------------------------------------------------------------------------------
B 1   AGG11           aabb.cc00.0399 Et0/0.100    IngOk       RlyMPDB
                      Forwarded      Et0/1.100    EgrOK       aabb.cc00.0299
B 2   AGG31           aabb.cc00.0499 Et0/0.100    IngOk       RlyMPDB
                      Forwarded      Et0/1.100    EgrOK       aabb.cc00.0399
! 3   UPE31           aabb.cc00.0599 Et0/0.100    IngOk       RlyHit:MEP
                      Not Forwarded               aabb.cc00.0499
```

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE Notification

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

····▶   ELMI Status Enquiry message (Full Status report)

◀────   ELMI Status message (Full Status report)

Example:

Local UNI ID	CE11_UNI
CE-VLAN/EVC Map type	Service_Multiplexing
EVC ID	EVC_P2P_100
EVC Type	Point_to_Point
CE-VLAN/EVC Map	vlan 100
EVC Status	New, Active
Remote UNI count – configured	1
Remote UNI count – active	1
Remote UNI ID	CE31_UNI
Remote UNI status	UP

Cisco enhancements to ELMI

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE Notification

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

▶ **·····▶** 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

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

Network Stable:
Remote UNI shows
UP

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE Notification—VLAN ID Missmatch

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

CE Configured with the correct C-VLAN (e.g. vid 100)
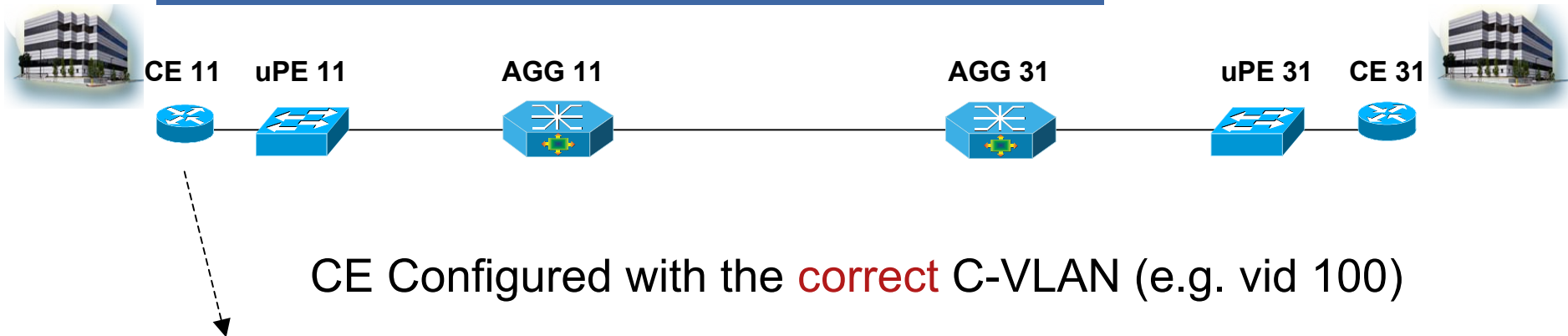
```
CE11(config)#interface gig0/0.100
CE11(config-subif)#encapsulation dot1Q 100

CE11#show ip interface brief
Interface          IP-Address      OK? Method Status        Protocol
<snip>
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 11   uPE 11   AGG 11   AGG 31   uPE 31   CE 31

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_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
<snip>
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

CE   Access   Aggregation   Aggregation   Access   CE

X

CFM remote MEP timeout   CFM remote MEP timeout

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

ELMI Status message   ELMI Status message
Async EVC report   Async EVC report

ELMI action: ELMI action:
CE brings down   CE brings down
(sub)interface   (sub)interface

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

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

Error DB

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 ethernt cfm errors

MPID Domain Id   Mac Address   Type Id Lvl
    MAName   Reason   Age

3100 PROVIDER_DOMAIN   aabb.cc00.0599 Vlan   100 4
    customer_100_provider   Lifetime Timer Expired 119s

Cisco-defined alarm

IEEE-defined alarm

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE 11   uPE 11   AGG 11   X   AGG 31   uPE 31   CE 31
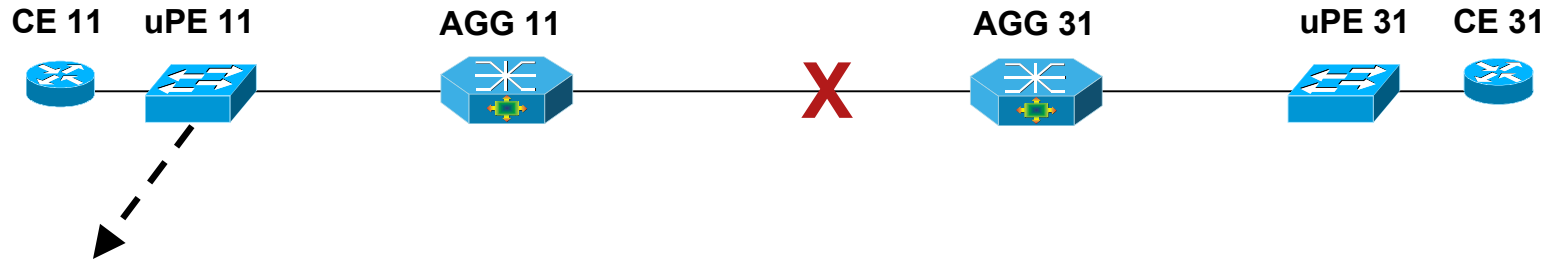
UPE11#**ping ethernet aabb.cc00.0599 domain PROVIDER_DOMAIN vlan 100**

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

                        MAC   Ingress   Ingr Action Relay Action
  Hops   Host   Forwarded   Egress   Egr Action   Previous Hop
----
B 1   **AGG11**   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   X   AGG 31   uPE 31   CE 31
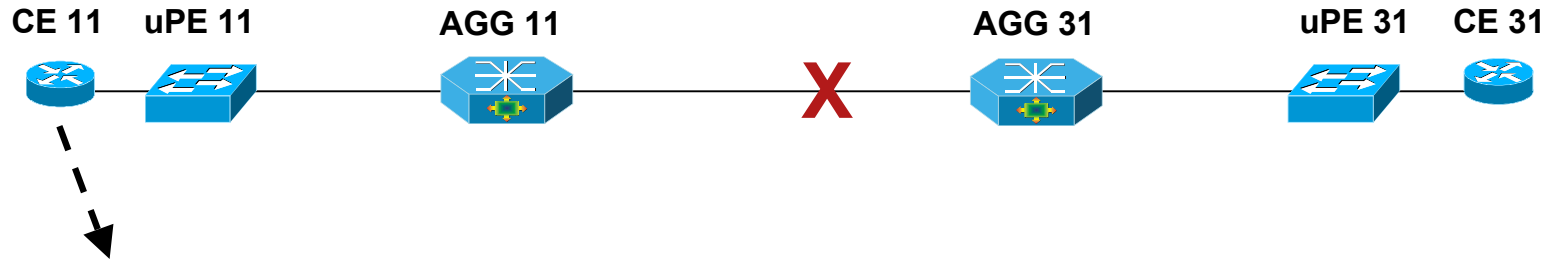
```
CE11#

*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

CE   Access   Aggregation   Aggregation   Access   CE

UNI Link Down

EVC declared Inactive

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 Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE 11   uPE 11   AGG 11   AGG 31   uPE 31   CE 31
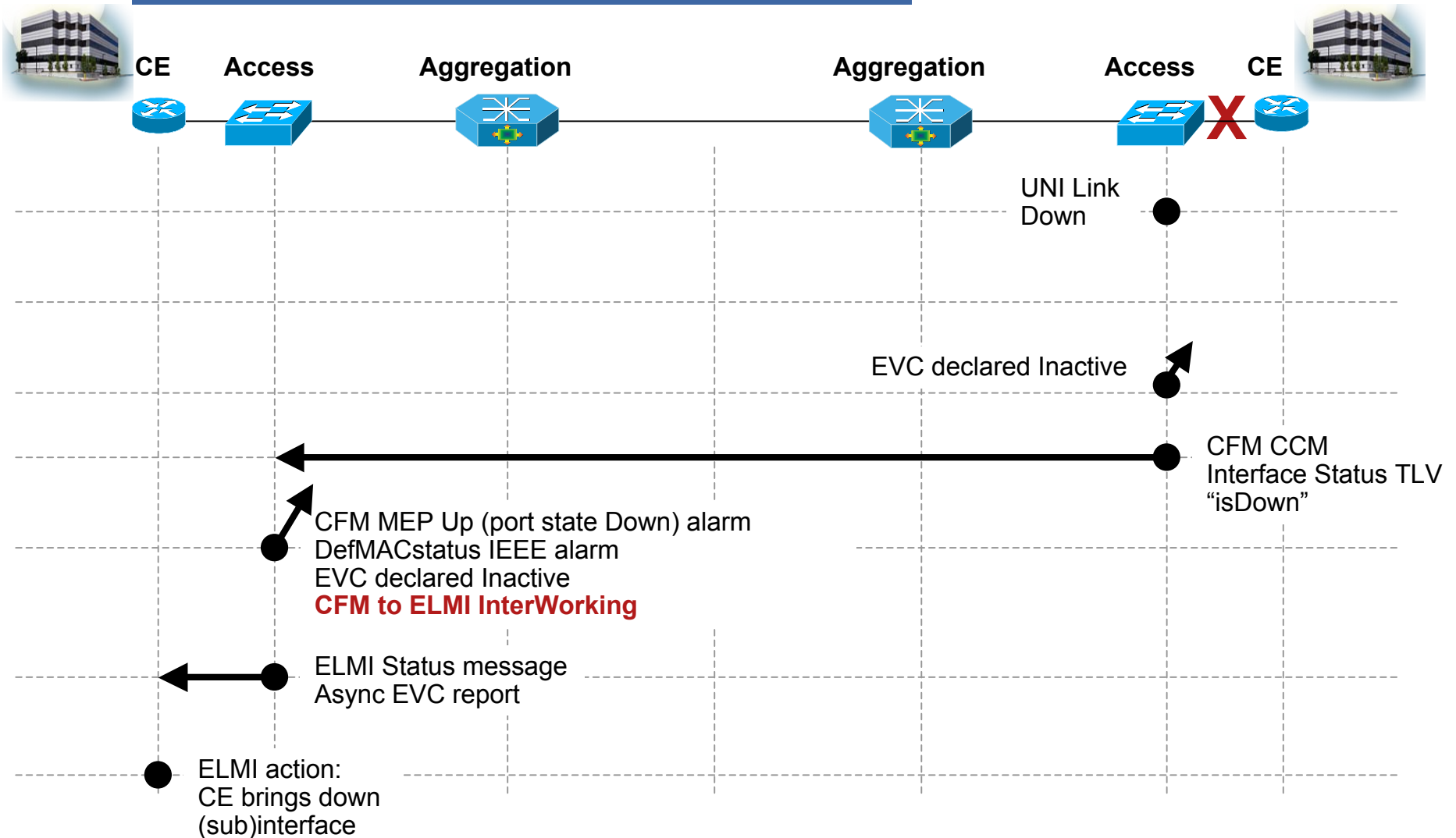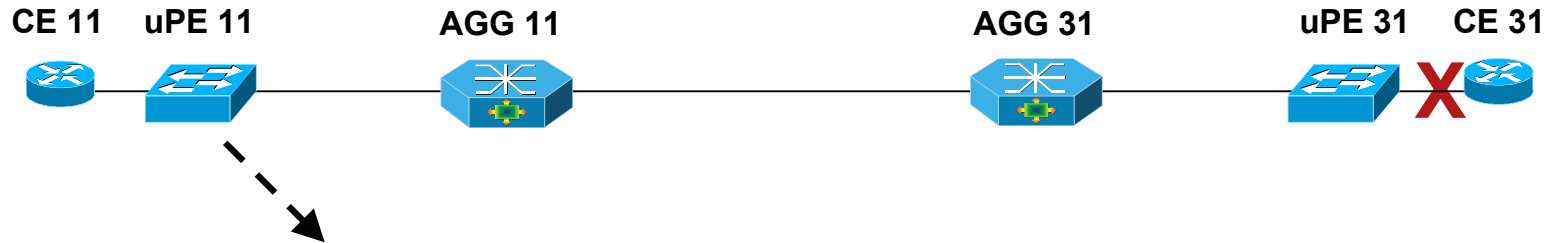
UPE11#

*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

MPID Domain Name   MacAddress   IfSt PtSt
 Lvl Domain ID   Ingress
 RDI MA Name   Type Id   SrvcInst
    EVC Name   Age

3100 PROVIDER_DOMAIN   aabb.cc00.0599   Down Up
 4   PROVIDER_DOMAIN   Et0/1.100
 -    customer_100_provider   Vlan 100   N/A
    N/A   0s

Total Remote MEPs: 1

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

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

```
CE11#

*Apr  8 04:41:54.907: %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

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

UNI Failure:
Remote UNI shows DOWN

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Failure Scenario: UNI Admin Shutdown

CE   Access   Aggregation   Aggregation   Access   CE

UNI admin
Shutdown at CE

CE transmits
802.3ah Dying Gasp

802.3ah alarm
EVC declared Inactive
802.3ah to CFM InterWorking

CFM CCM
Organization-specific TLV
AdminDown

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

Cisco enhancement
to CFM

ELMI Status message
Async EVC report

ELMI action:
CE brings down
(sub)interface

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Failure Scenario: Power Failure at CE

CE   Access   Aggregation   Aggregation   Access   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 Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Failure Scenario: UNI Errors (Detected by CE)

Receive Errors detected by CE

CE   Access   Aggregation   Aggregation   Access   CE

CE exceeds 802.3ah
HIGH error threshold

CE sends 802.3ah
Event OAM PDUs

802.3ah to CFM InterWorking
EVC declared Inactive

CFM CCM
Organization-specific TLV
remoteExcessiveErrors

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

Cisco enhancement
to CFM

ELMI Status message
Async EVC report

ELMI action:
CE brings down
(sub)interface

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Failure Scenario: UNI Errors (detected by SP)

Receive Errors detected by SP

CE   Access   Aggregation   Aggregation   Access   CE

SP exceeds 802.3ah
HIGH error threshold

SP sends 802.3ah
Event OAM PDUs

802.3ah to CFM InterWorking
EVC declared Inactive

CFM CCM
Organization-specific TLV
localExcessiveErrors

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

Cisco enhancement
to CFM

ELMI Status message
Async EVC report

ELMI action:
CE brings down
(sub)interface

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE   PE   EoMPLS Pseudowire   PE   CE

Point-to-Point Ethernet Service

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

CE   **PE**   EoMPLS Pseudowire   **PE**   **CE**

E-LMI   **Directed LDP session**   **E-LMI**

PW OAM
To E-LMI IW   **PW OAM**
To E-LMI IW

OAM Protocol Positioning

Deploying Carrier Ethernet OAM
Ethernet Layer 2 VPN Services

Failure Scenario: UNI Failure

CE   PE   EoMPLS Pseudowire   PE   CE

CE UNI failure:
Admin "shutdown"

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

ELMI Status message
Async EVC report

ELMI action:
CE brings down
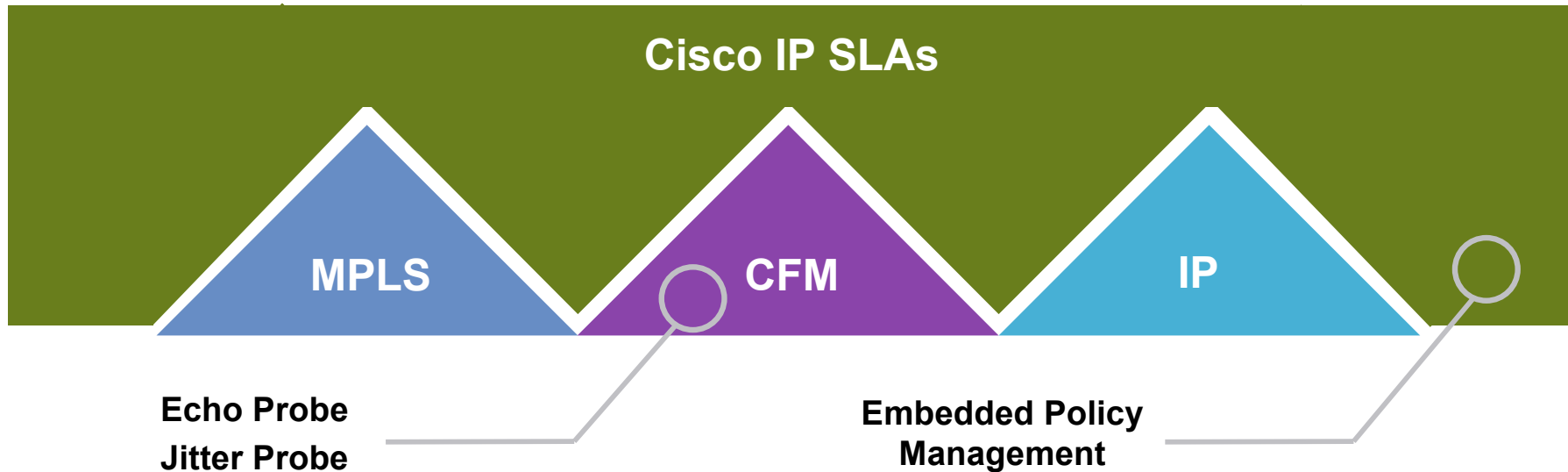(sub)interface
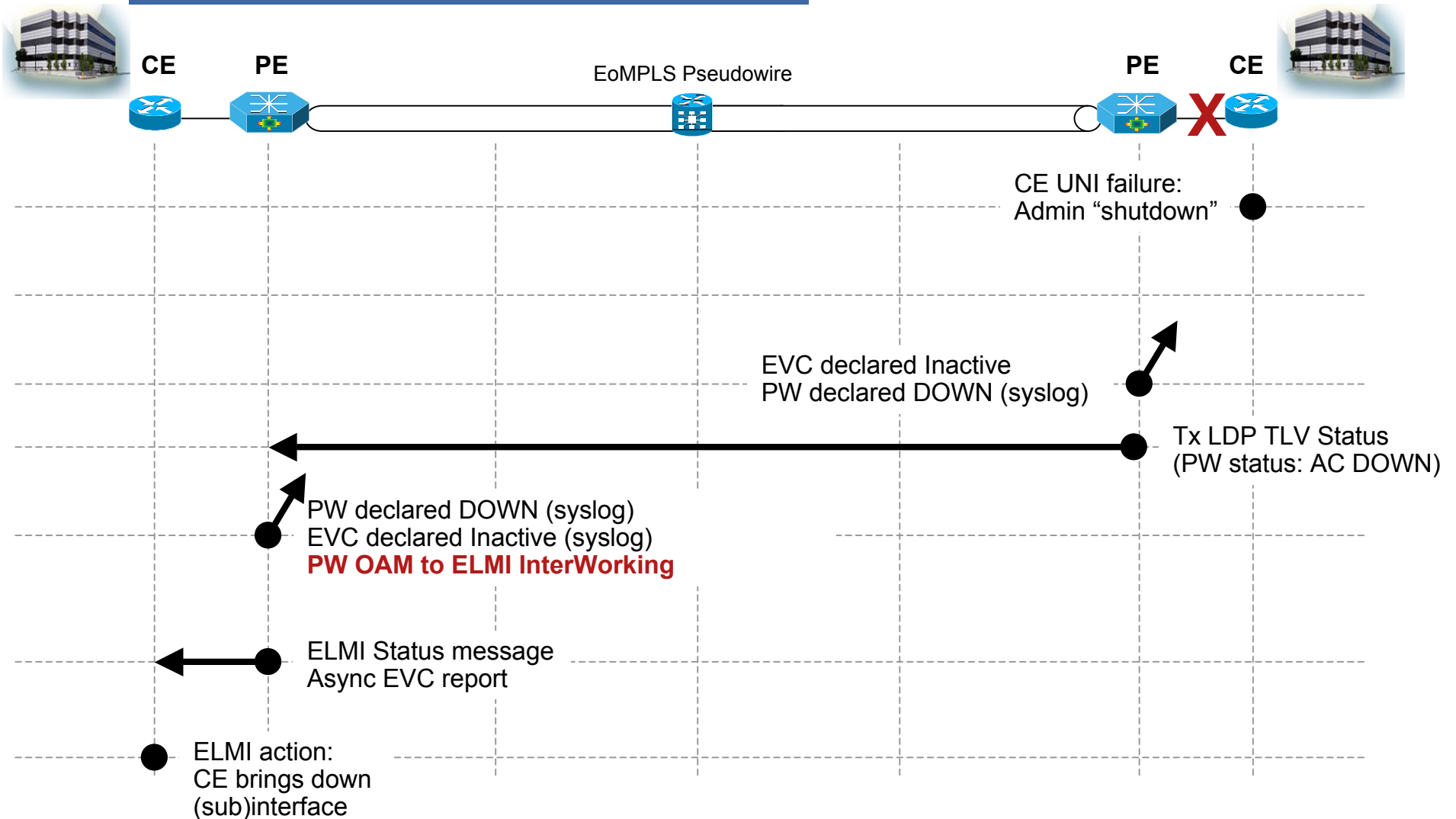
Ethernet Performance Management

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
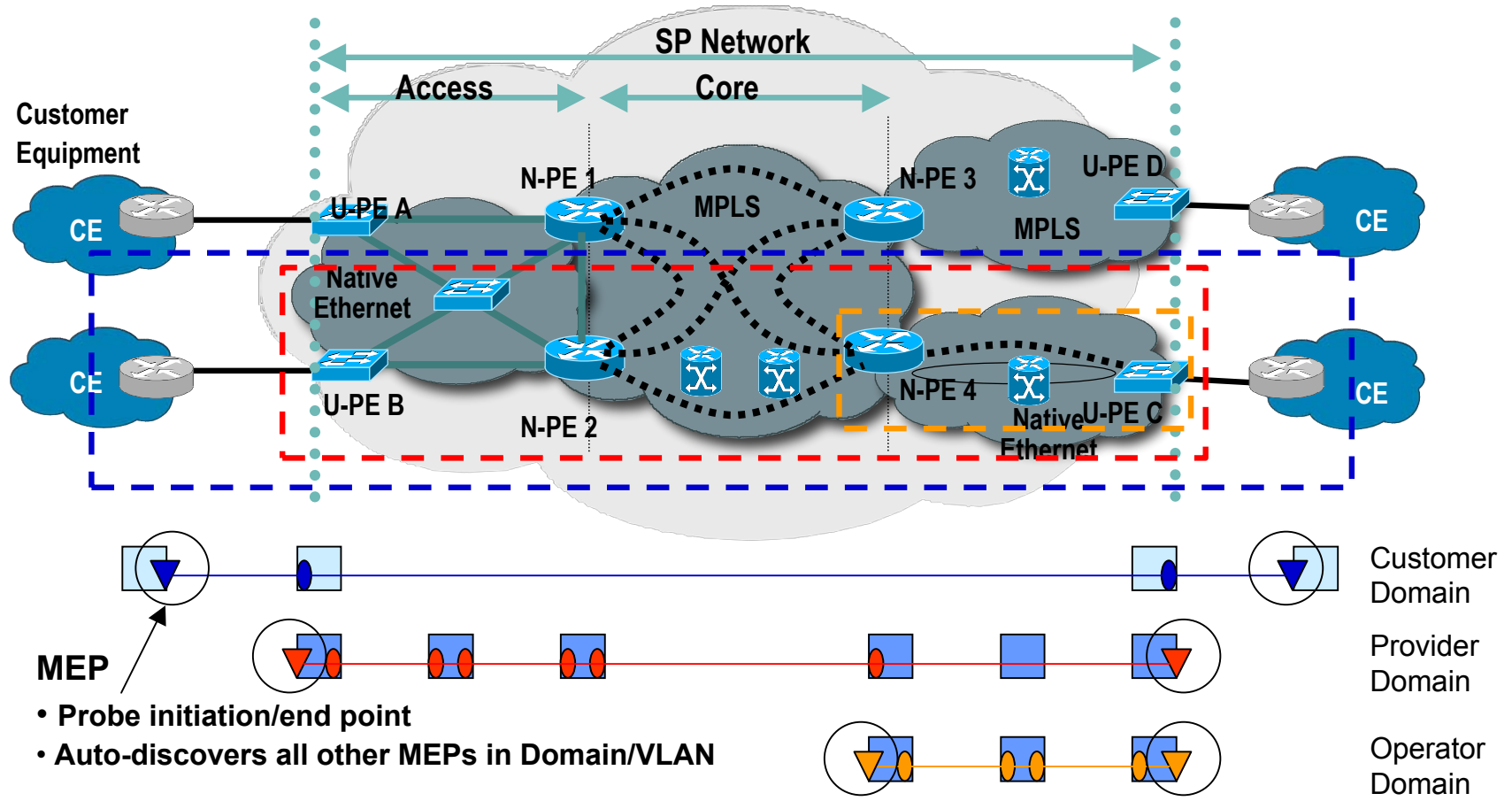
IP SLA
Ethernet Probe Types

Probe Type	Capability
Echo Probe	Per service, ethernet probe Uses CFM LBM/LBR PDUs Measures RTT
Jitter Probe	Per service, ethernet probe Uses proprietary CFM messages Measures uni-directional packet loss, jitter and latency

IP SLA
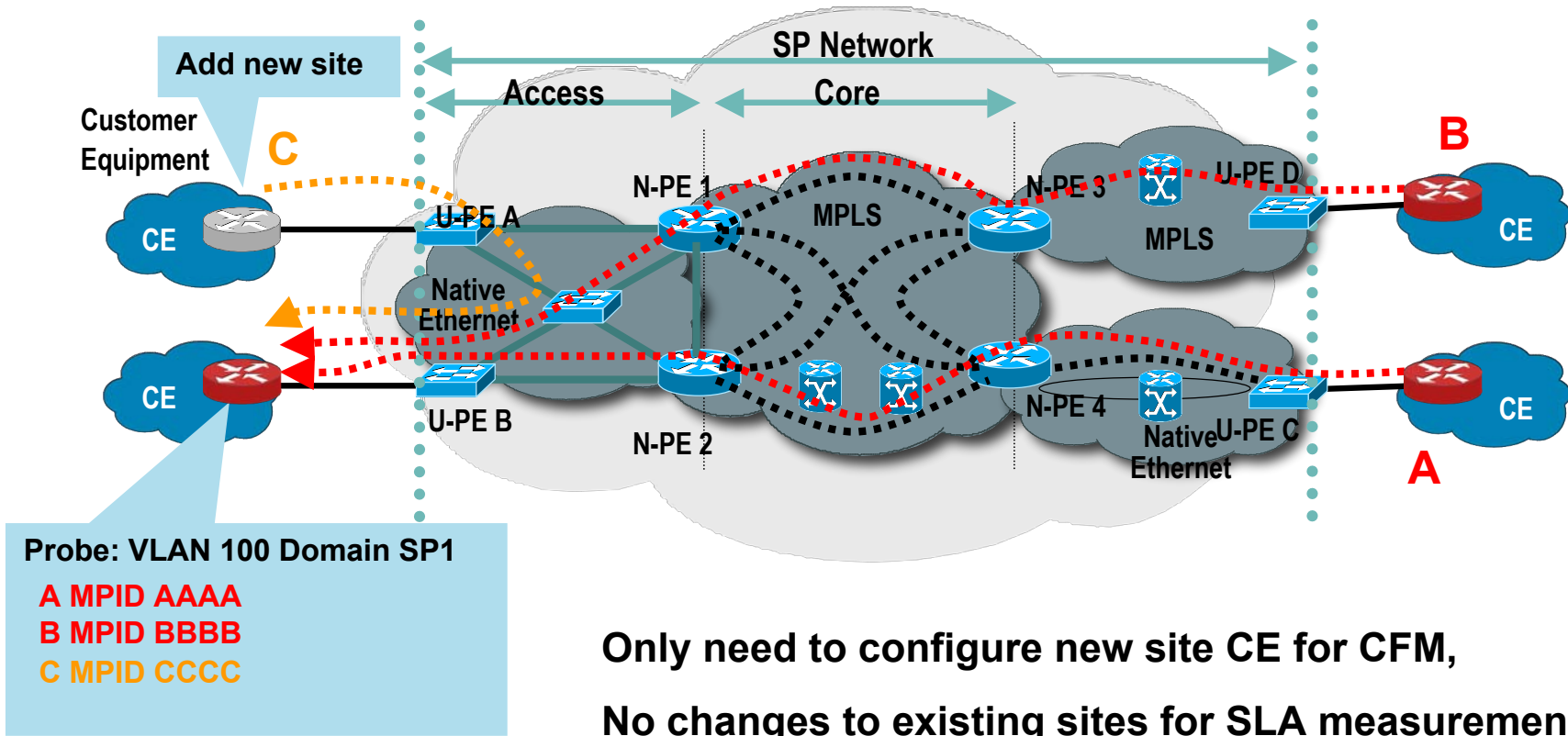## Hierarchical Performance Management

- 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

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)

Add new site

Customer Equipment

C

SP Network

Access   **Core**

B

CE

U-PE A

N-PE 1

MPLS

N-PE 3

U-PE D

CE

Native Ethernet

MPLS

CE

U-PE B

N-PE 2

N-PE 4

Native Ethernet

U-PE C

CE

A

Probe: VLAN 100 Domain SP1

A MPID AAAA
B MPID BBBB
C MPID CCCC

Only need to configure new site CE for CFM,

No changes to existing sites for SLA measurement.

Acronyms

Acronym	
AIS	Alarm Indication Signal
CCM	Continuity Check Message
CCMDB	CCM Data Base (see CCM)
CE	Customer Edge
CFM	Connectivity Fault Management
EFM	Ethernet in the First Mile
E-LMI	Ethernet LMI (see LMI)
E-OAM	Ethernet OAM (see OAM)
EVC	Ethernet Virtual Connection
IEEE	Institute of Electrical and Electronics Engineers
ITU	International Telecommunication Union
LBM	Loopback Message
LBR	Loopback Reply
LMI	Local Management Interface
LTM	Linktrace Message
LTR	Linktrace Reply
MA	Maintenance Association
MAID	MA Identifier (see MA)
MD	Maintenance Domain

Acronym	
MEF	Metro Ethernet Forum
MEN	Metro Ethernet Network
MEP	Maintenance Association End Point
MEPID	MEP Identifier (see MEP)
MHF	MIP Half Function (see MIP)
MIB	Management Information Base
MIP	Maintenance Domain Intermediate Point
MP	Maintenance Point
OAM	Operations, Administration and Maintenance
PDU	Protocol Data Unit
PE	Provide Edge
RDI	Remote Defect Indicator
RFI	Remote Failure Indicator
TLV	Type, Length, Value
UNI	User to Network Interface
UNI-C	Customer side of UNI (see UNI)
UNI-N	Network side of UNI (see UNI)
VID	VLAN Identifier
VLAN	Virtual LAN

Q and A

Acknowledgement

- Jose Liste, TME-Cisco Systems

 Cisco Public