Carrier Ethernet

Operations, Administration & Maintenance

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Acknowledgement

- Jose Liste
- Sudarshan Pathalam

Agenda

- OAM Overview
- Ethernet OAM – Protocol Overview
  - IEEE 802.3ah – Link OAM, also known as EFM
  - IEEE 802.3ag – Connectivity Fault Management (CFM)
  - ITU Y.1731 – Fault & Performance Management
  - MEF E-LMI – Configuration Management
- Ethernet Service Activation Testing
- OAM Interworking
- Sample Fault Management Scenarios
- Ethernet OAM Deployment Use Cases
- Summary

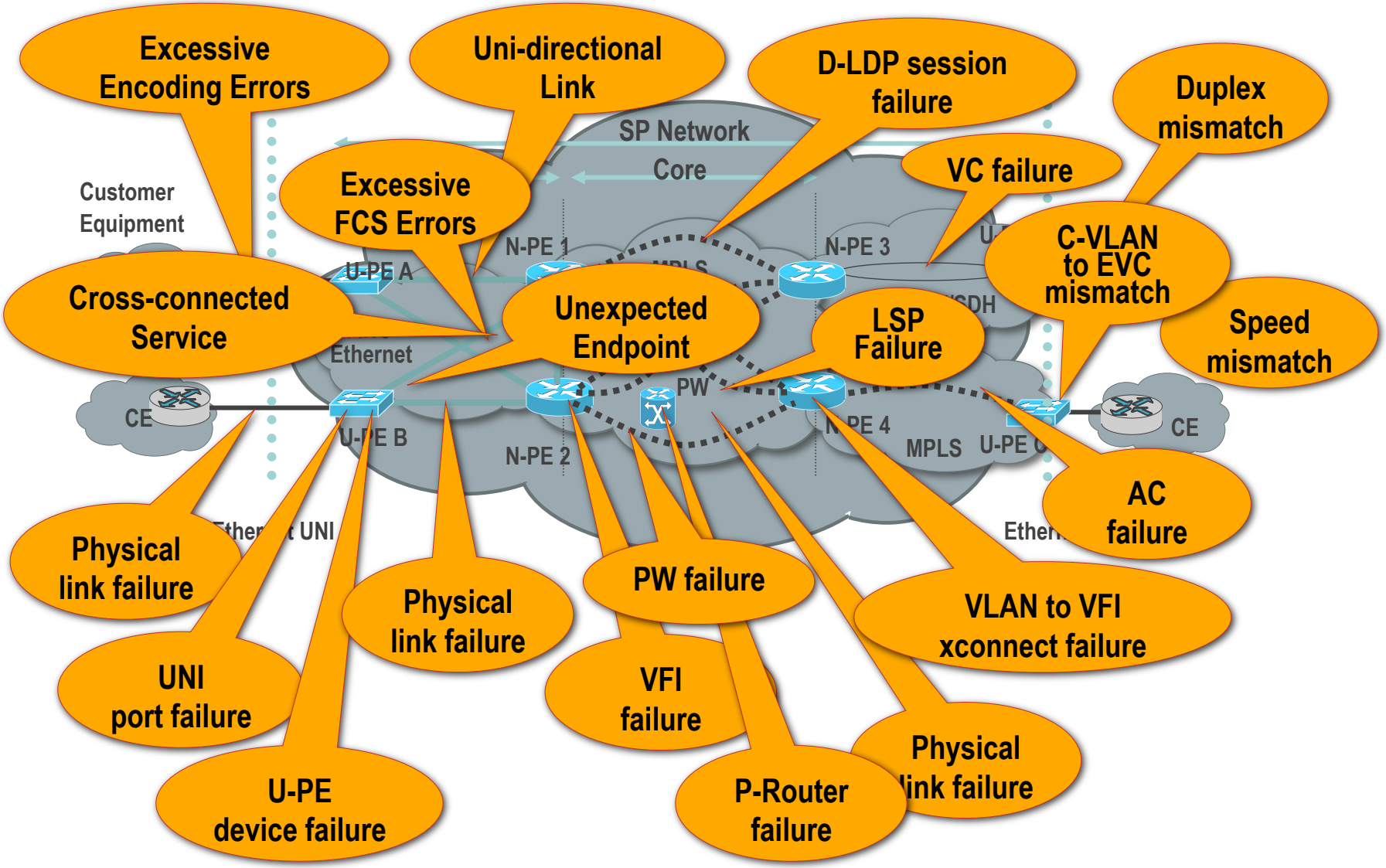
Operations, Administration & Maintenance

- **F** – Fault Management
- **C** – Configuration Management
- **A** – Accounting
- **P** – Performance Management
- **S** – Security Management

OAM Protocols and Mechanisms helps operator to achieve some of the FCAPS functionality

OAM capability is one of the key differentiator to make a SP network truly “Carrier Grade”

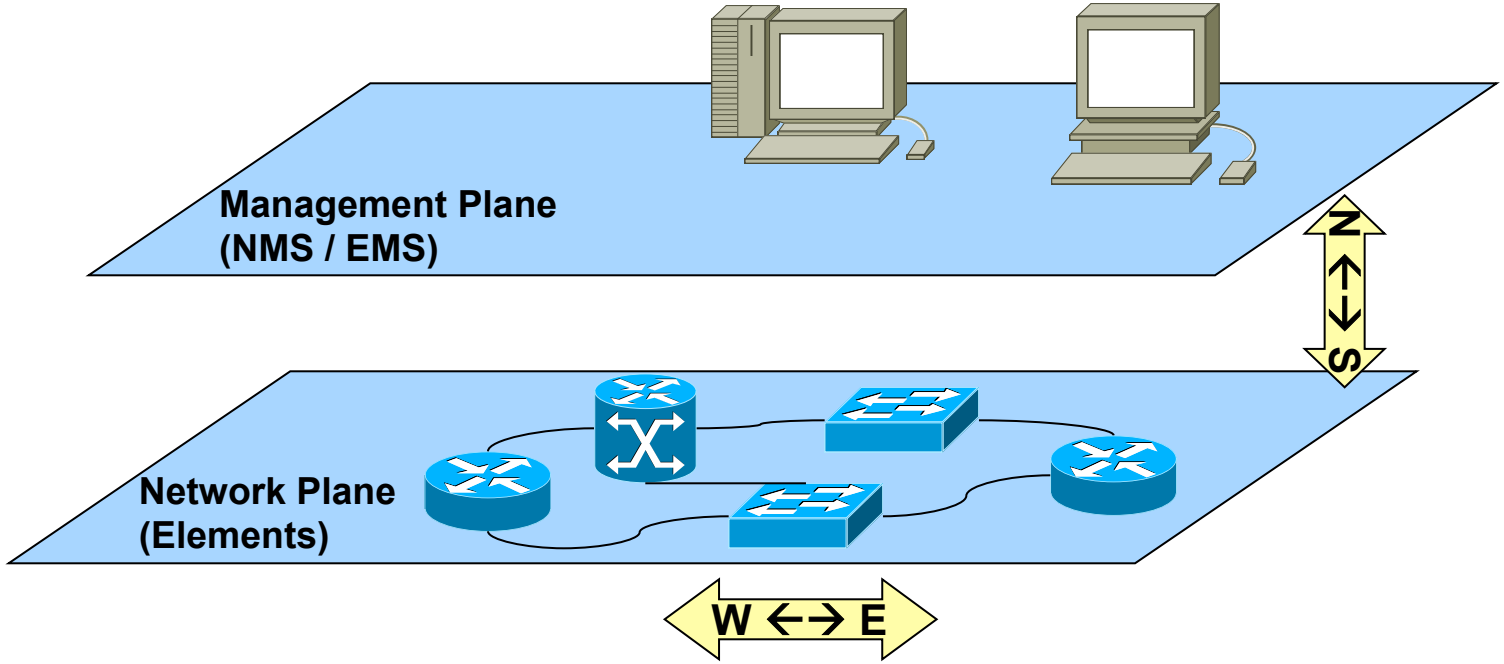
Problem Scope
A few possible scenarios



OAM: The Concept

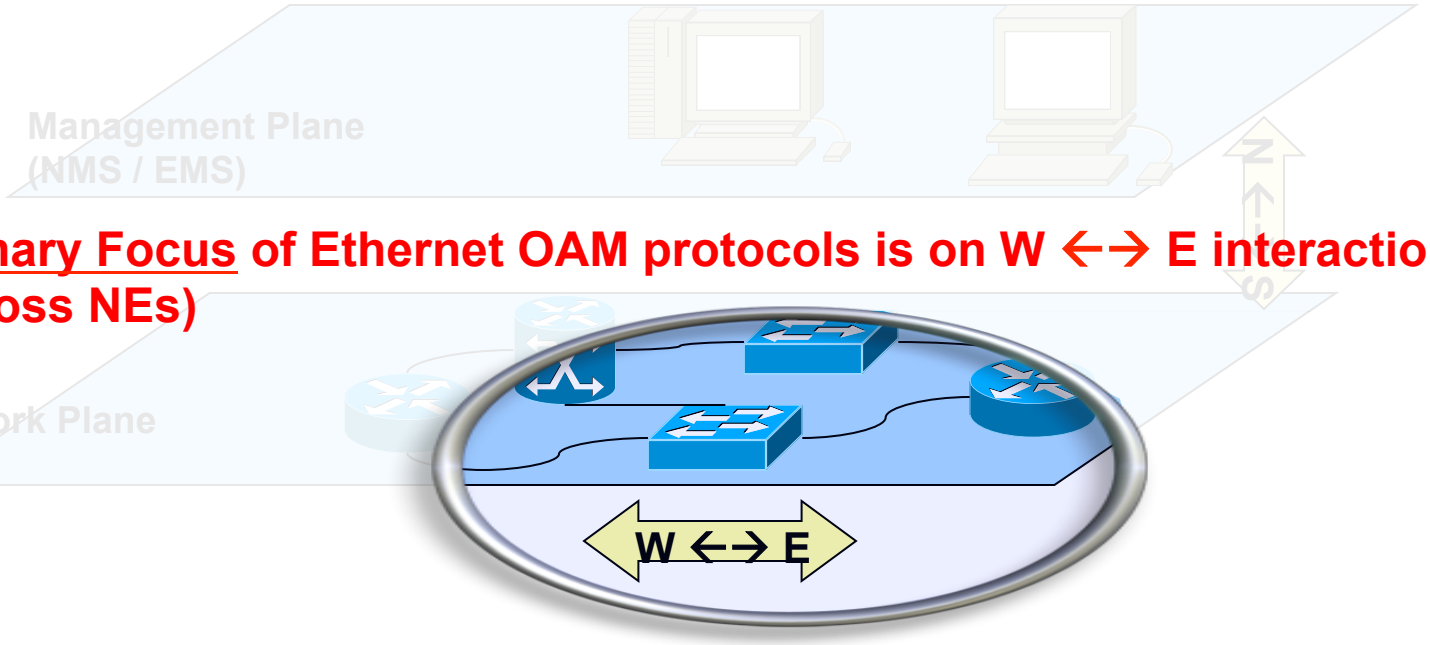
- **Operations, Administration, Maintenance & Provisioning:**
  - **fault indication**
  - **performance monitoring**
  - **security management**
  - **diagnostic functions**
  - **configuration & service provisioning**

- **OAM covers both N←→ S and W←→E interfaces**



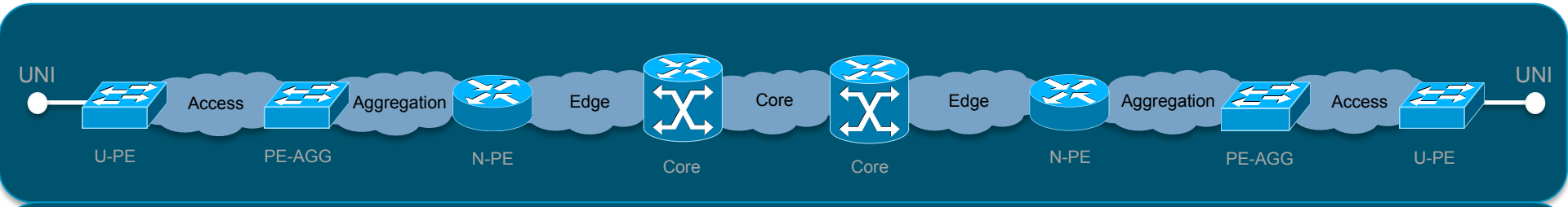
Scope of Ethernet OAM

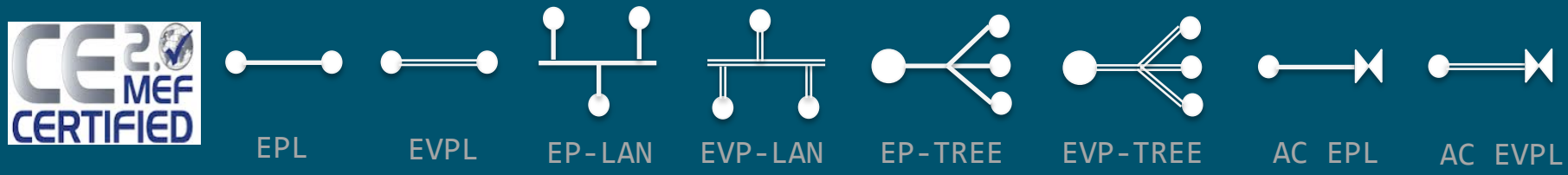
- **O**perations, **A**dministration, **M**aintenance & Provisioning:
  - fault indication
  - performance monitoring
  - security management
  - diagnostic functions
  - configuration & service provisioning
- OAM covers both N←→ S and W←→E interfaces



Primary Focus of Ethernet OAM protocols is on W ←→ E interactions (across NEs)

Focus Areas of Ethernet OAM





CE Services &
Network Infrastructure

Fault Management

Fault Detection
Fault Notification
Fault Verification
Fault Isolation
Fault Recovery

Config Management

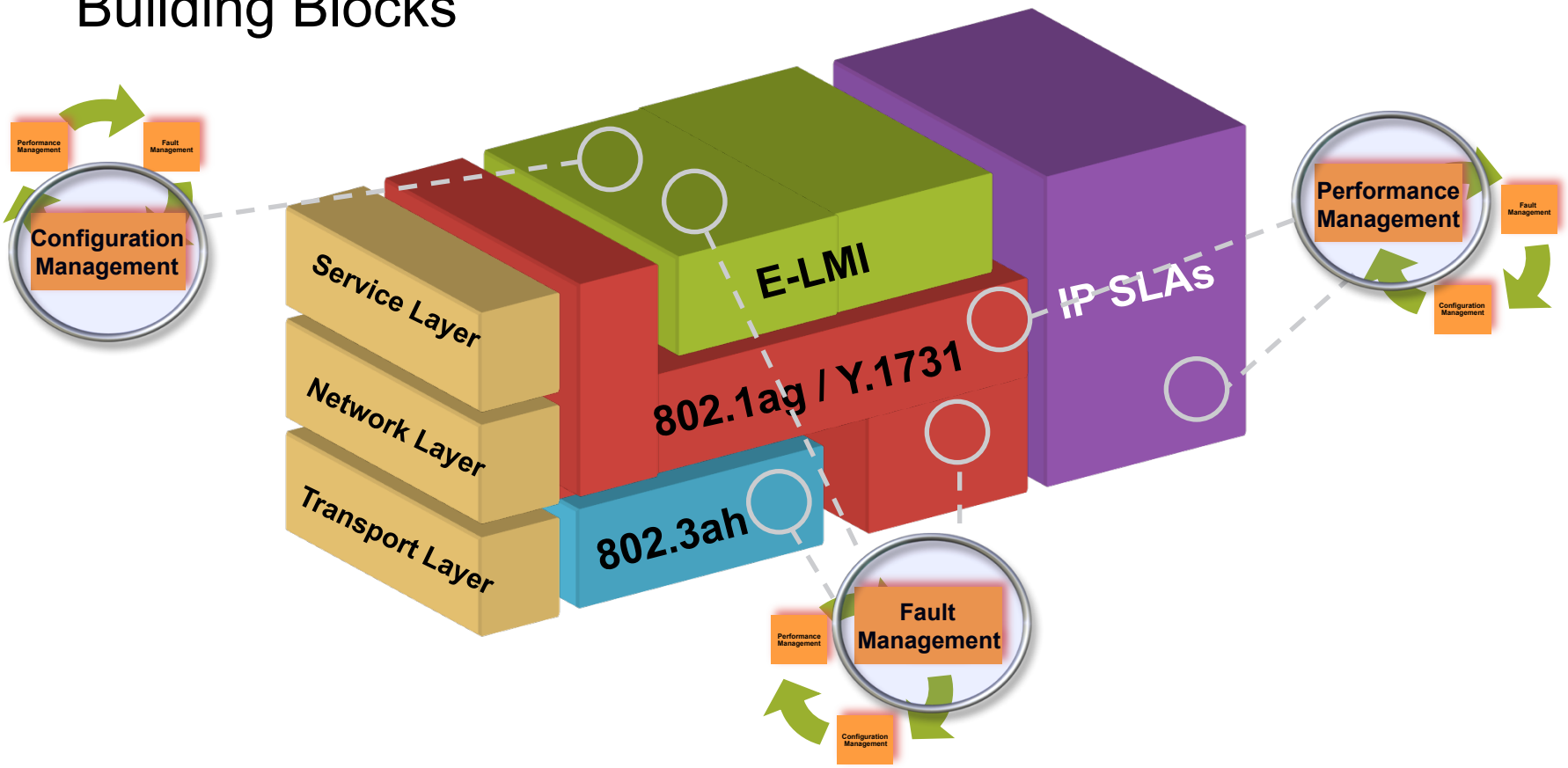
Service Provisioning

Performance Management

Frame Loss Measurement
Delay Measurement
Delay Variation Measurement
Availability Measurement

Ethernet OAM

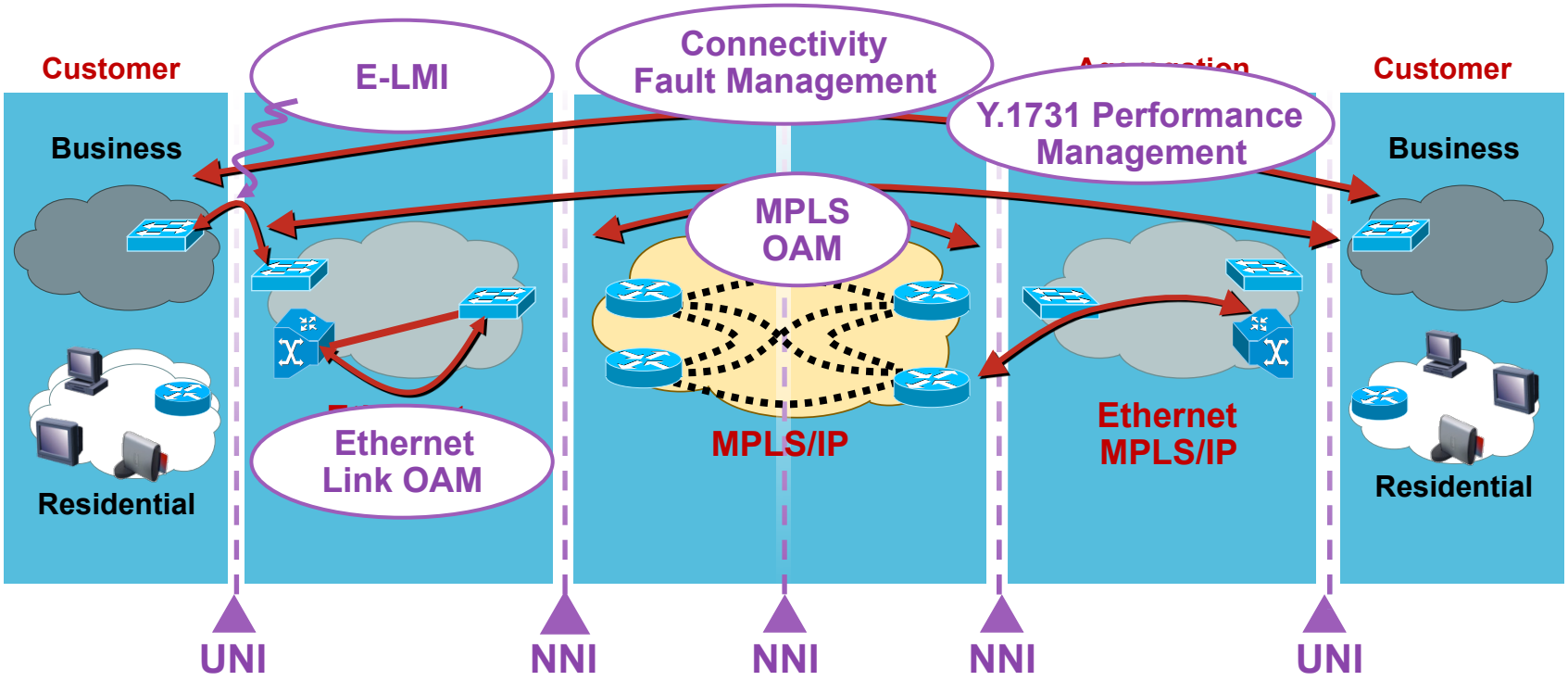
Building Blocks



- IEEE 802.1ag: Connectivity Fault Management (CFM)
- IEEE 802.3ah: Ethernet Link OAM (EFM OAM)
- ITU-T Y.1731: OAM functions & mechanisms for Ethernet based networks
- MEF E-LMI: Ethernet Local Management Interface
- IP SLA's: Performance Management using CFM and Y.1731 mechanisms

Carrier Ethernet OAM

Protocol Positioning

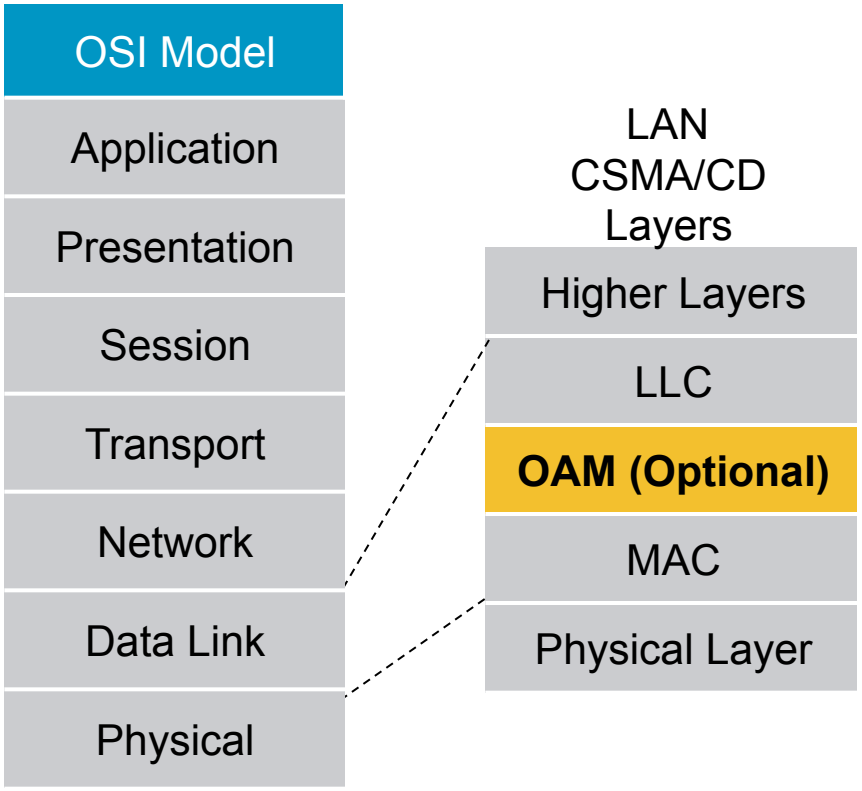


- E-LMI – User to Network Interface (UNI)
- Link OAM – Any point-point 802.3 link
- CFM, Y.1731 PM – End-to-End UNI to UNI
- MPLS OAM – within MPLS cloud

IEEE 802.3ah (Clause 57) Link OAM

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)



(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 MIB Variable Retrieval

  Ability to read one or more MIB variables from the remote DTE

- 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

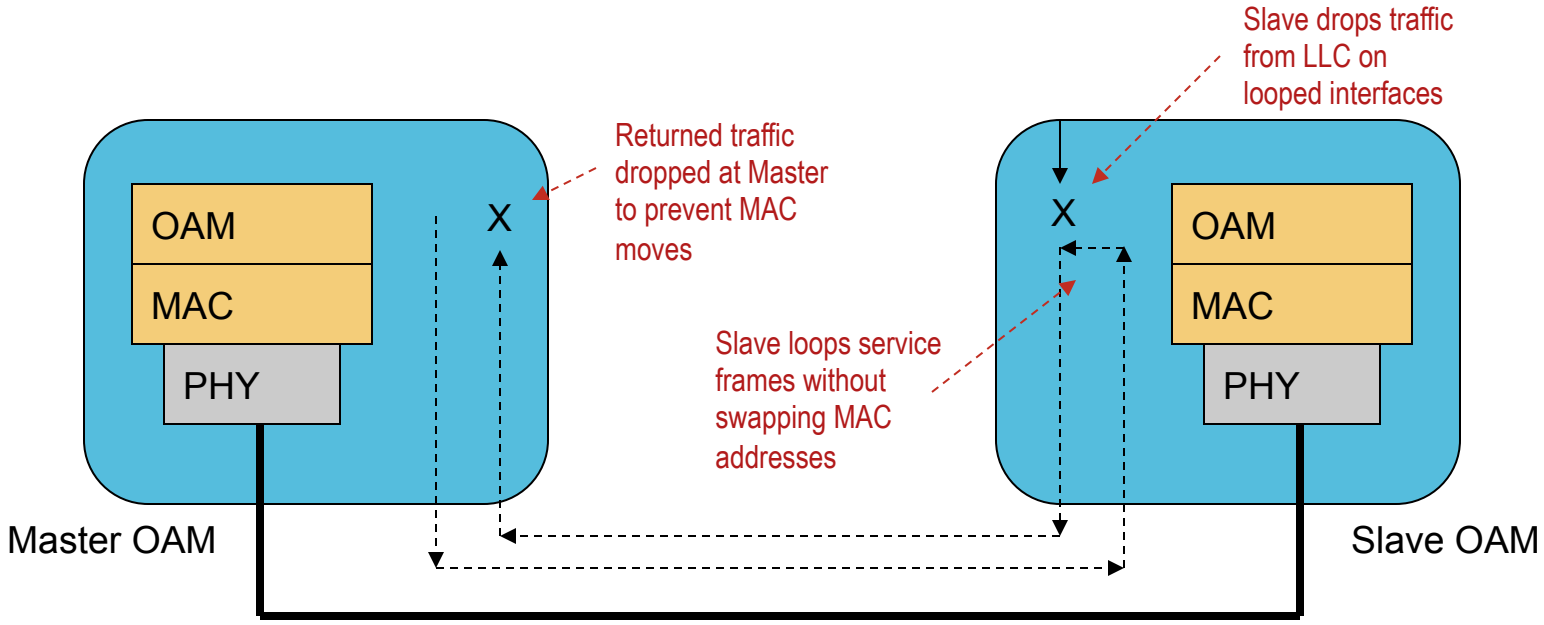
IEEE 802.3ah

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 intrusive 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



IEEE 802.1ag: Connectivity Fault Management (CFM)

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 2007

  IEEE std. 802.1ag-2007

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CFM Overview (Cont.)

Key CFM Mechanisms

- 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

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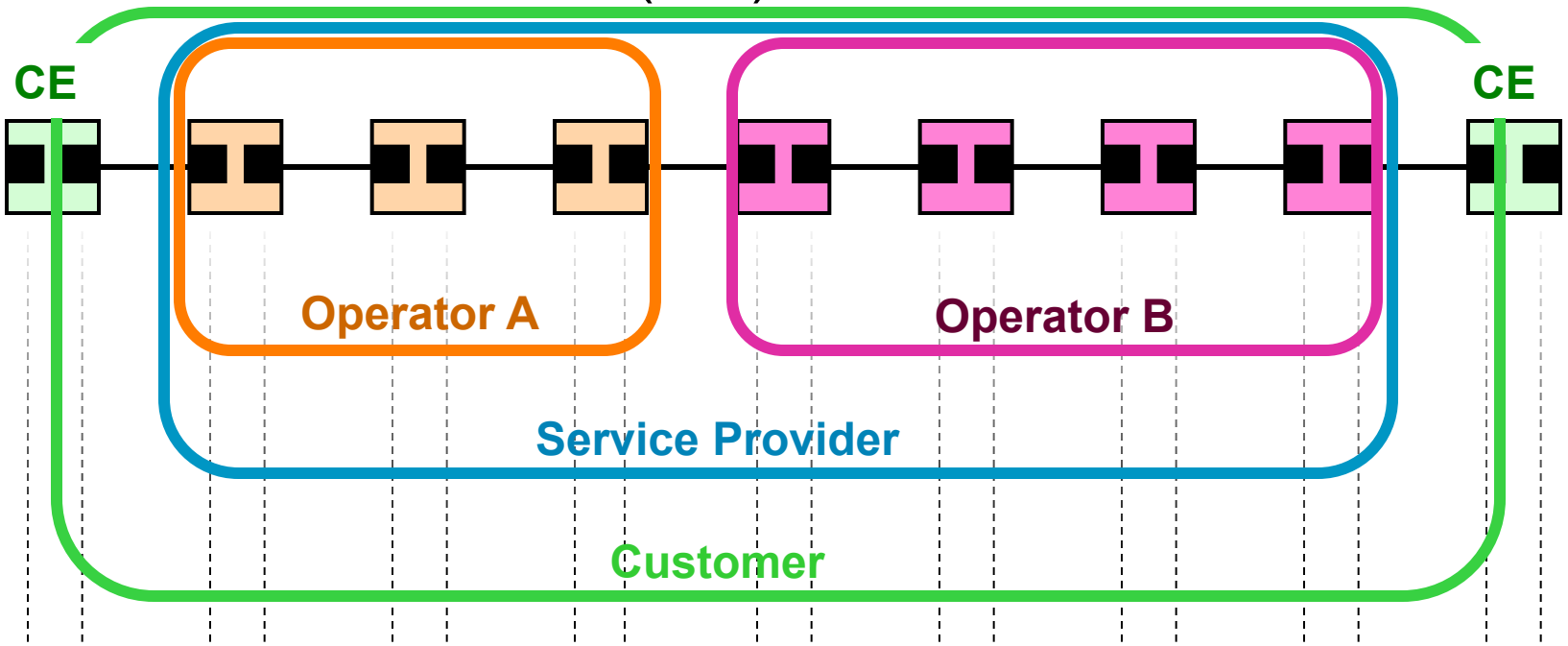
CFM Concepts

Maintenance Domain (MD)



- Defined by Operational/Contractual Boundaries
  - e.g. Customer / Service Provider / Operator
- MD may nest and touch, but never intersect
- Up to eight 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

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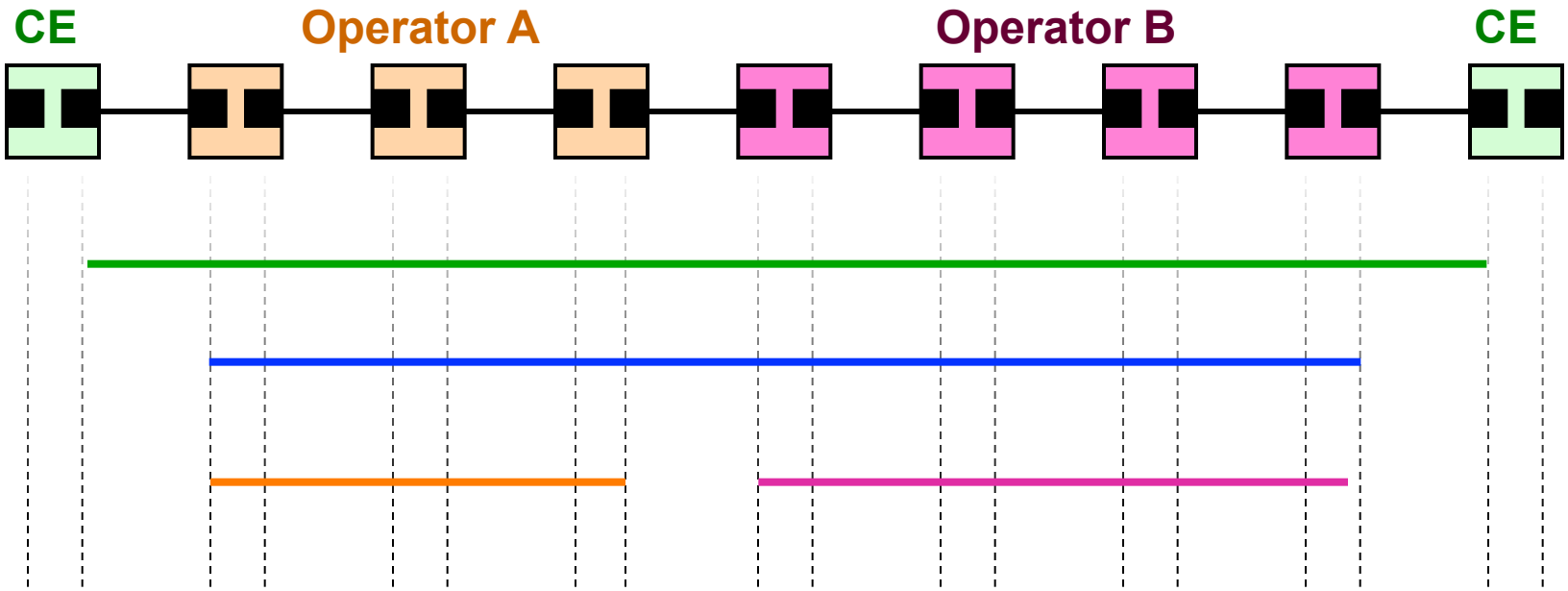
CFM Concepts

Maintenance Association (MA)



- Monitors connectivity of a particular service instance in a given MD (e.g. one service traversing four MDs = four 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

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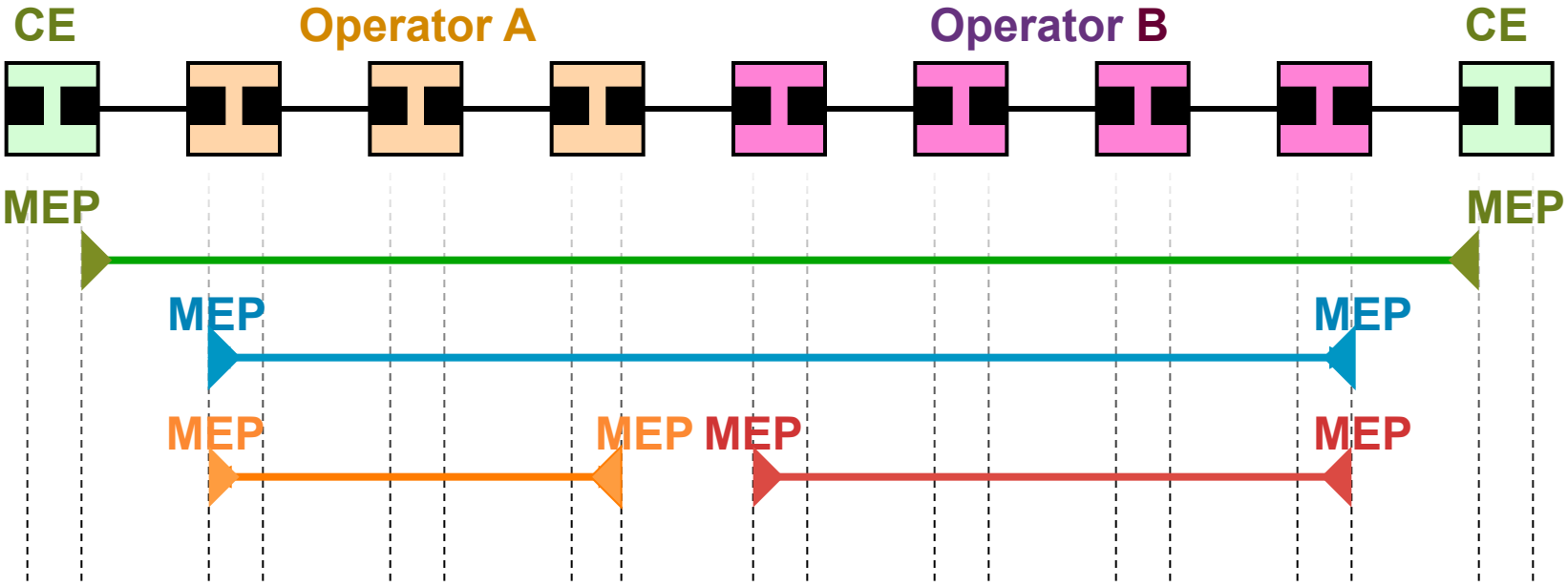
CFM Concepts

Maintenance Point (MP)—MEP



- **M**aintenance Association **E**nd **P**oint (**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

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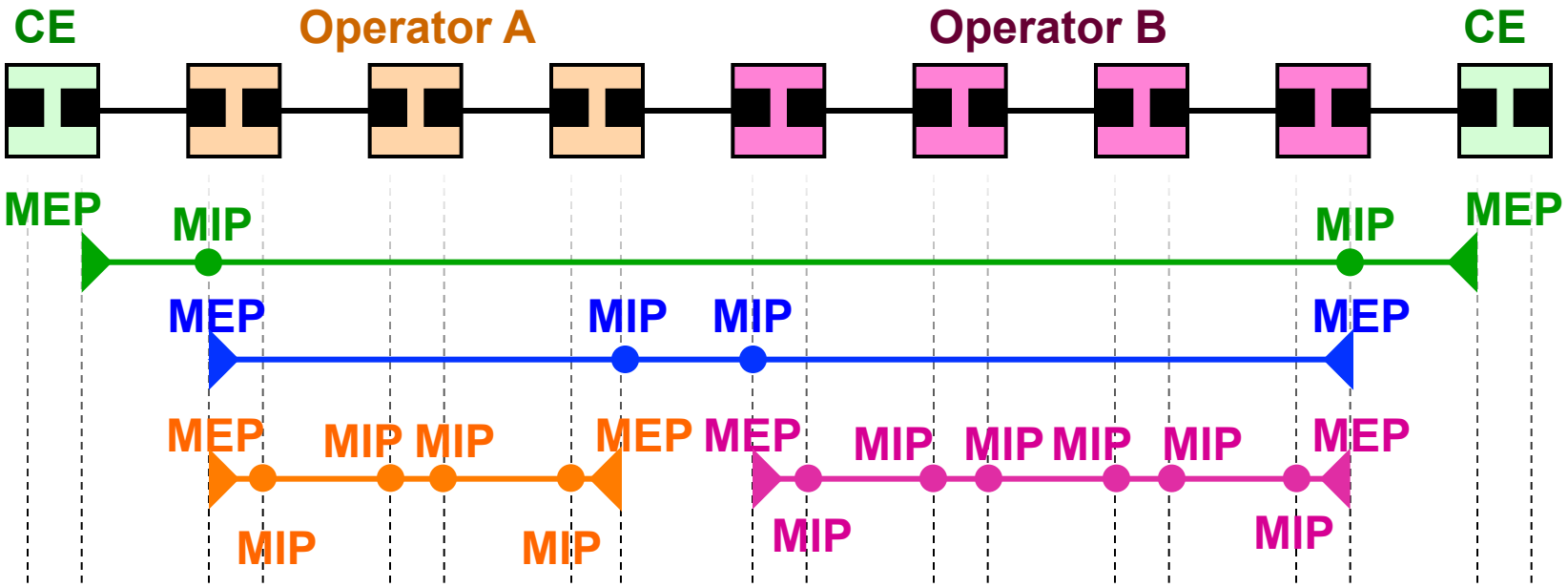
CFM Concepts

Maintenance Point (MP)—MIP



- **M**aintenance Domain **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

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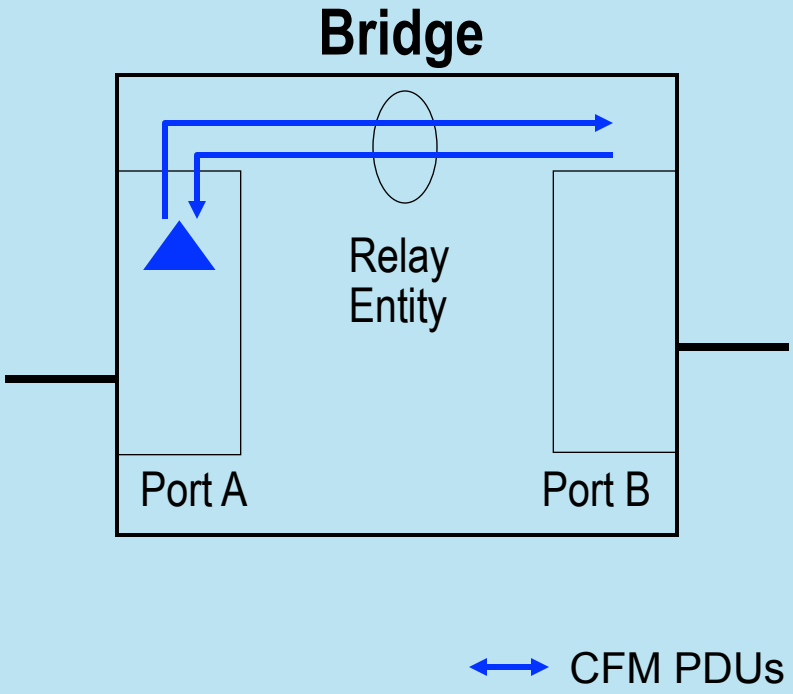
CFM Concepts
UP MEP

- 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



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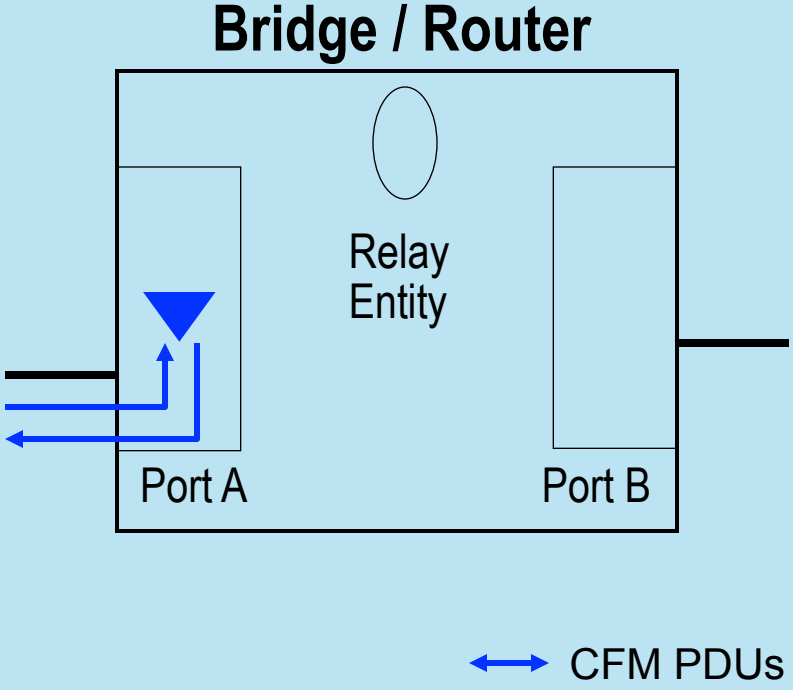
CFM Concepts
DOWN MEP

- 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



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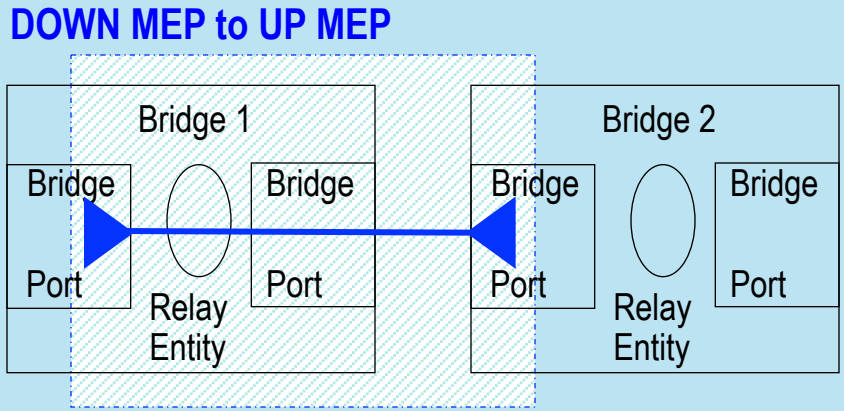
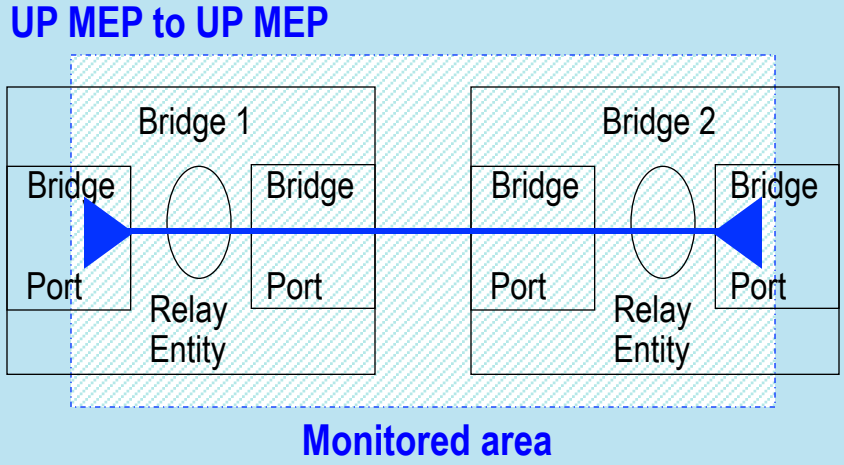
CFM Concepts

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)





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CFM Protocols

There are three (3) protocols defined by CFM

- Continuity Check Protocol
  - Fault Detection
  - Fault Notification
  - Fault Recovery
- Loopback Protocol
  - Fault Verification
- Linktrace Protocol
  - Path Discovery and Fault Isolation

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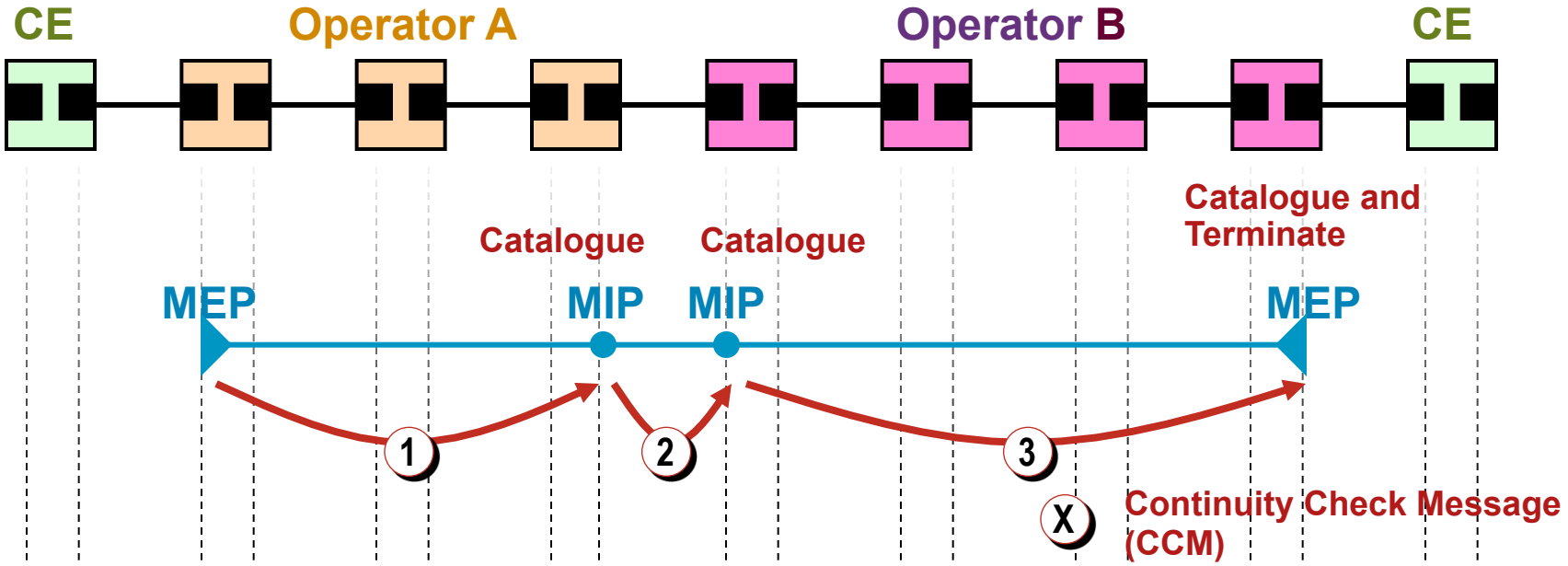
CFM Protocols

Continuity Check Protocol



- Used for Fault Detection, Notification and Recovery
- Per-Maintenance Association **multicast "heart-beat"** messages
  - Transmitted at a configurable periodic interval by MEPs (3.3ms, 10ms, 100ms, 1s, 10s, 1min, 10min)
  - 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

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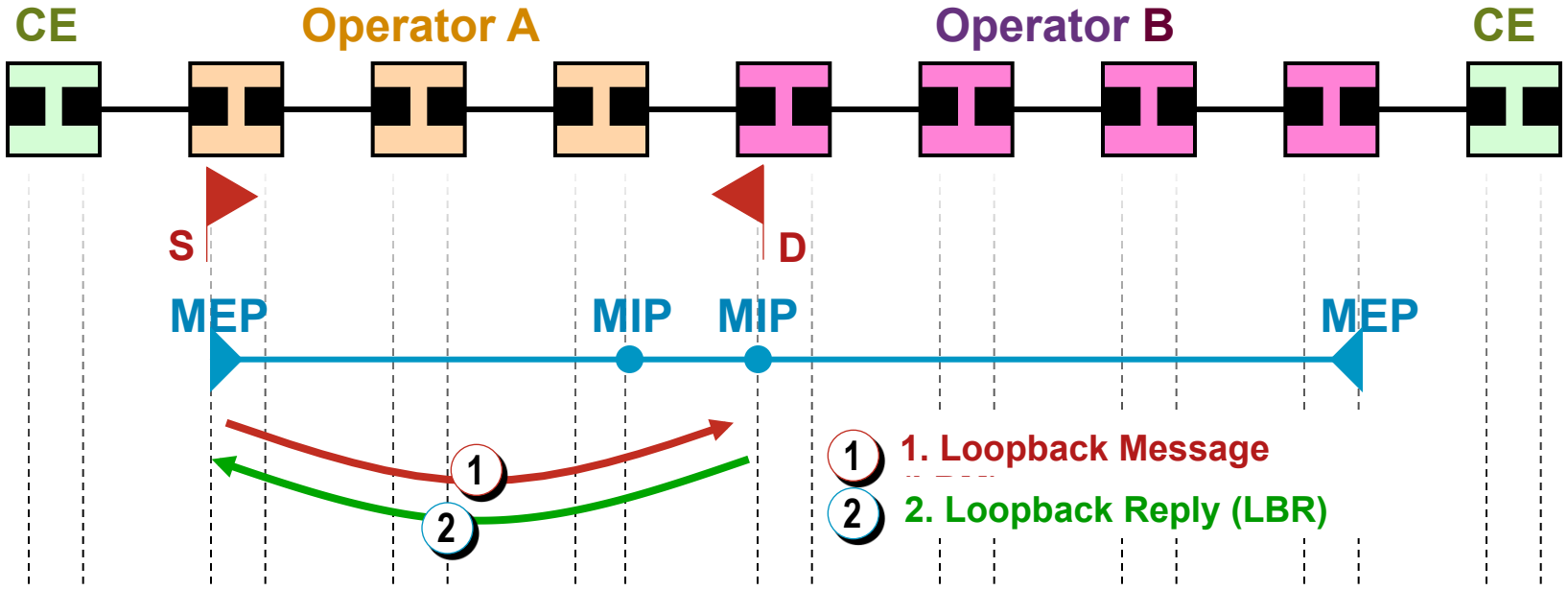
CFM Protocols

Loopback Protocol



- Used for Fault Verification—**Ethernet Ping**
- MEP can transmit a unicast LBM to a MEP or MIP in the same MA
- MEP can also transmit a multicast LBM (defined by ITU-T Y.1731), where only MEPs in the same MA respond
- Receiving MP responds by transforming the LBM into a unicast LBR sent back to the originating MEP

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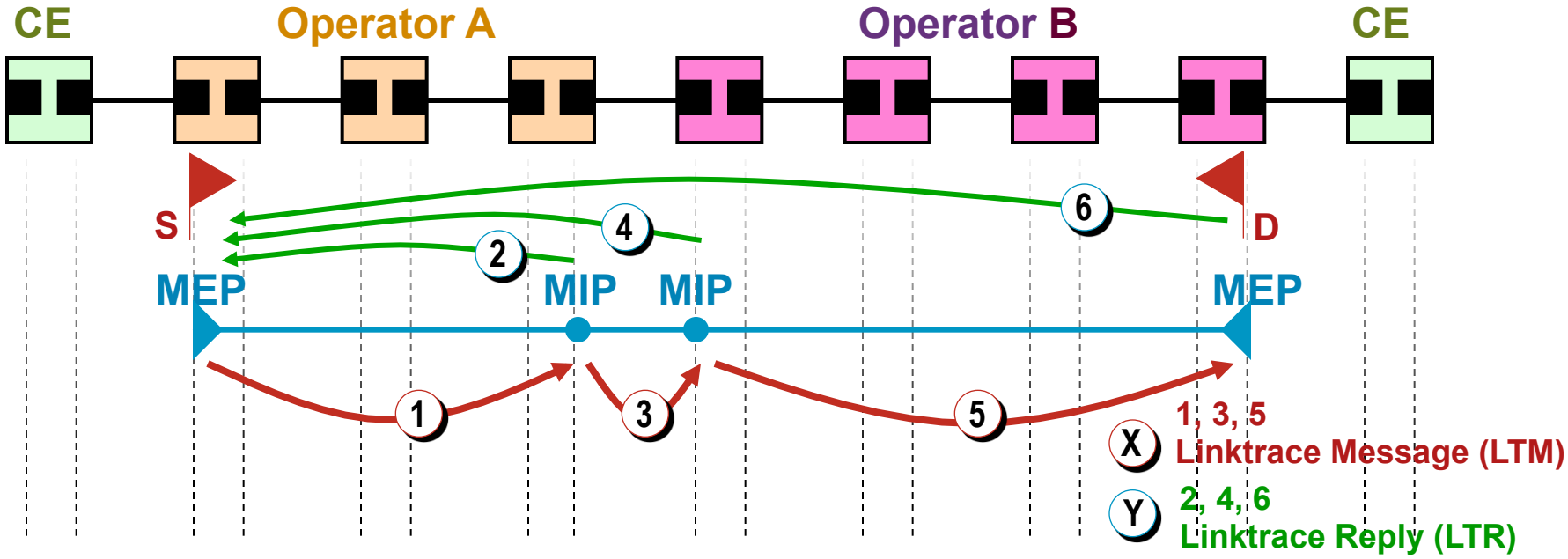
CFM Protocols

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

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ITU-T Y.1731 Overview

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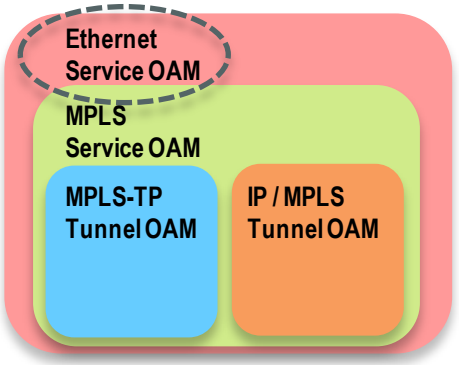
ITU-T Y.1731 Overview

- ITU-T recommendation that provides mechanisms for user-plane OAM functionality in Ethernet networks. It covers:

  Fault Management mechanisms

  Performance Management mechanisms



- Standardized by ITU-T SG 13 in May 2006

  Latest published version dated Feb. 2008 after IEEE 802.1ag standardization

- Frame formats (Multicast Address, Ethertype, and common OAM PDU fields) and base functionality are agreed upon across IEEE 802.1ag and Y.1731

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ITU-T Y.1731 Overview

- OAM Functions for Fault Management

Covered by IEEE 802.1ag

  - 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 Delay Measurement (ETH-DM)
  - Frame Loss Measurement (ETH-LM)
  - Frame Loss Measurement (ETH-SLM)

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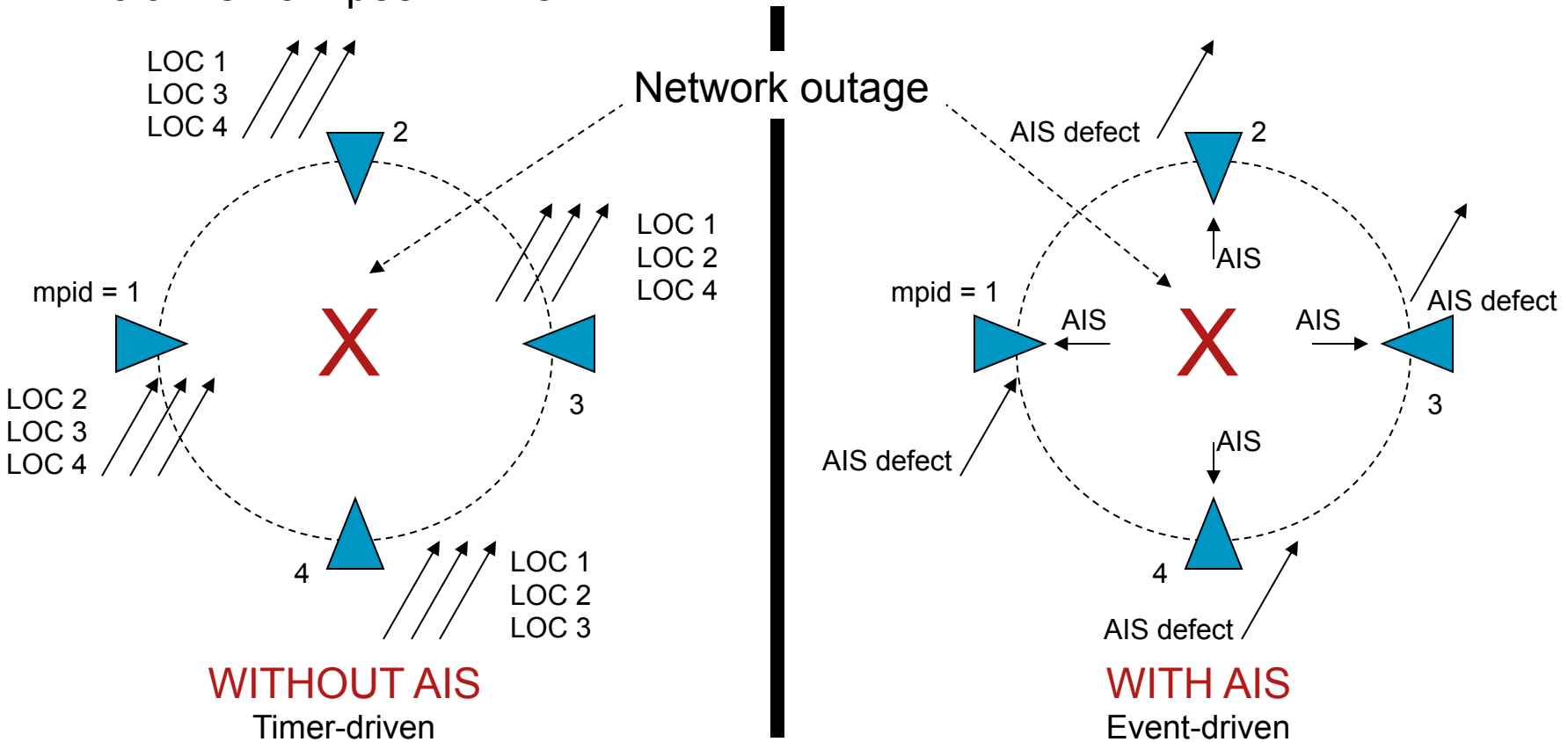
ETH-AIS – Alarm Indication Signal

LOC Alarm Suppression

- Without AIS, a MEP would report Loss of Continuity (LOC) for each of its remote MEPs upon timer expiration
- With AIS, if a MEP receives AIS from the network, it suppresses LOC alarms from peer MEPs



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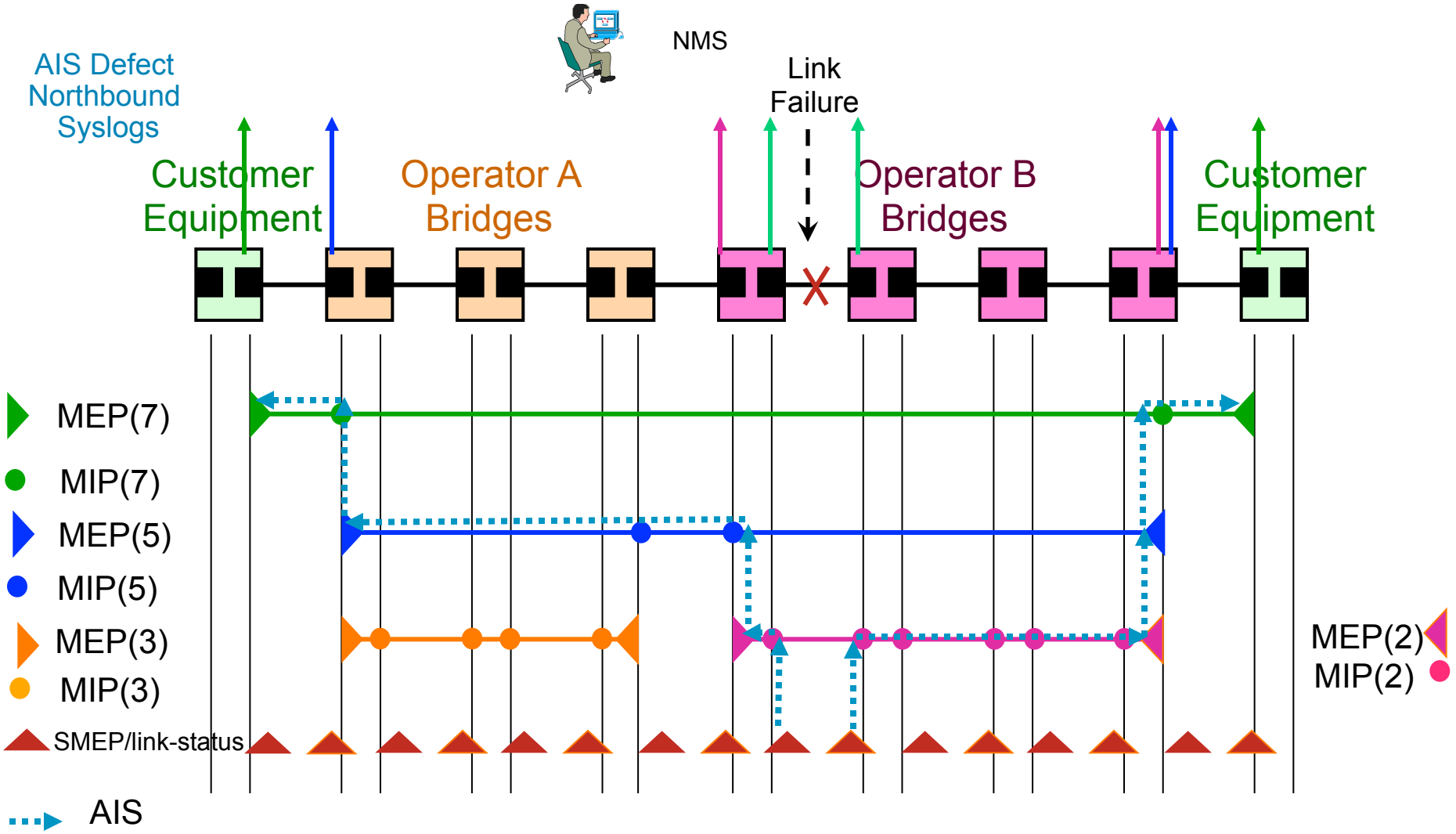
Alarm Indication Signal

Transport Path Failure propagation



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Y.1731 – Performance Management Functions

- Frame Loss Ratio – percentage (%) of service frames not delivered / Total number of service frames delivered in T time interval
- Frame Delay – round-trip/one-way delay for a service frame
- Frame Delay Variation – Variation in frame delay between a pair of service frame

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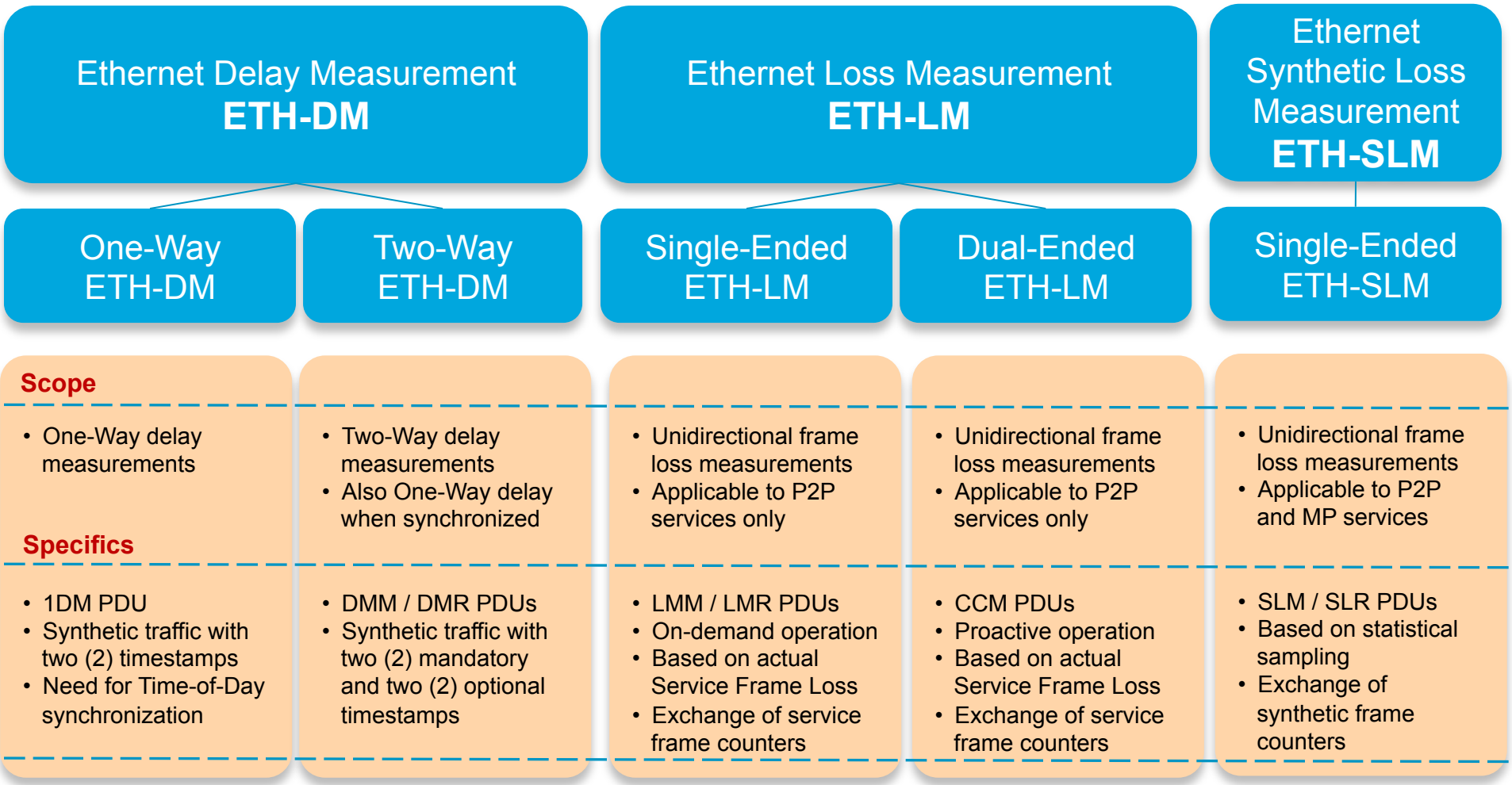
Ethernet Performance Management

ITU-T Y.1731 – Technology Overview



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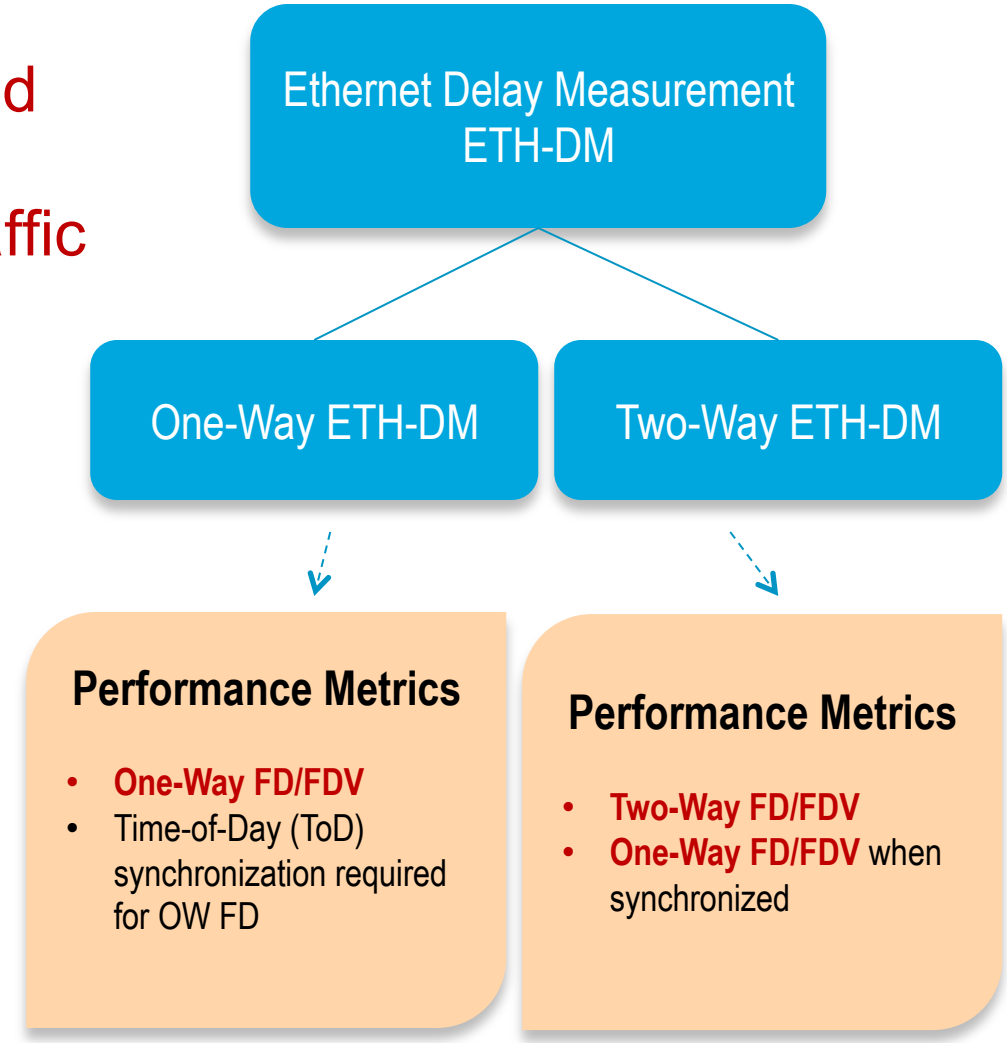
Y.1731 – Frame Delay Measurement

- Frame Delay calculated based on timestamps applied to synthetic traffic
- Applicable to point-to-point and multipoint services
- Two (2) mechanisms defined

  One-Way ETH-DM

  Two-Way ETH-DM



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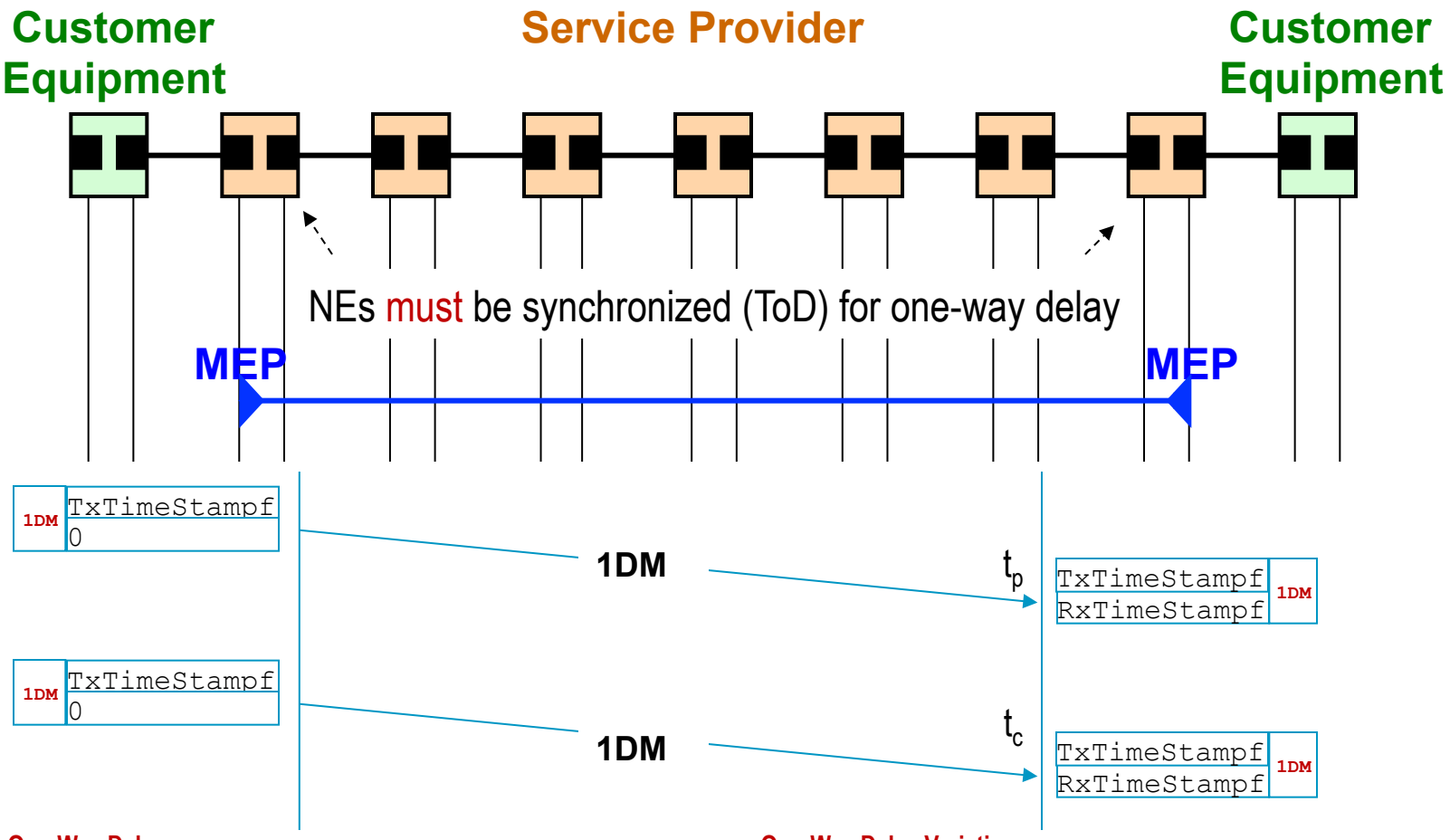
ITU-T Y.1731 Overview

One-Way ETH-DM



One-Way Delay

Delay = RxTimeStampf – TxTimeStampf

One-Way Delay Variation

Delay Var.[t_c] = Delay[t_c] – Delay[t_p]

t_p – Time Previous
t_c – Time Current

1DM – One-way Delay Measurement

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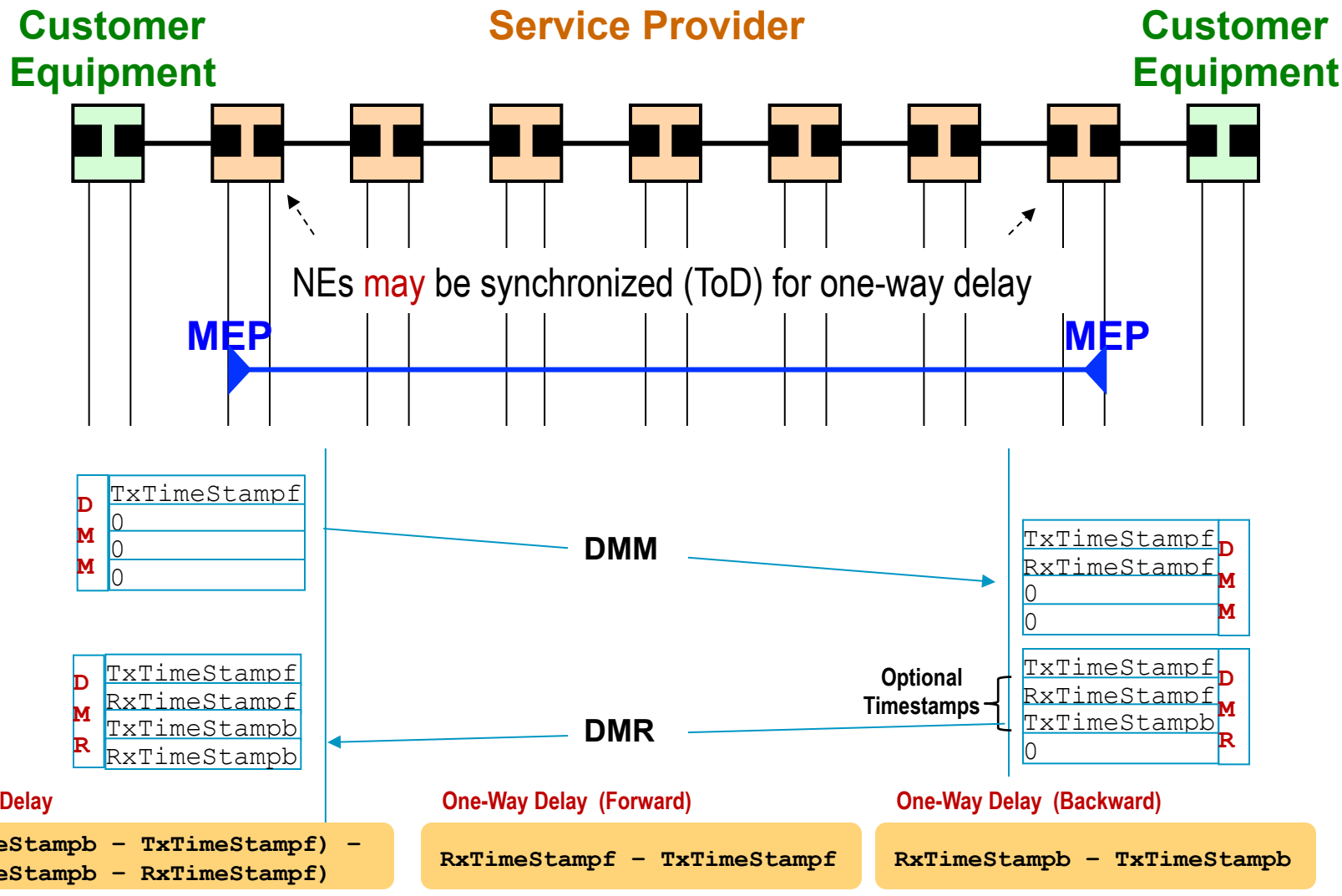
ITU-T Y.1731 Overview

Two-Way ETH-DM



DMM – Delay Measurement Message
DMR – Delay Measurement Reply

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Y.1731 – Frame Loss Measurement

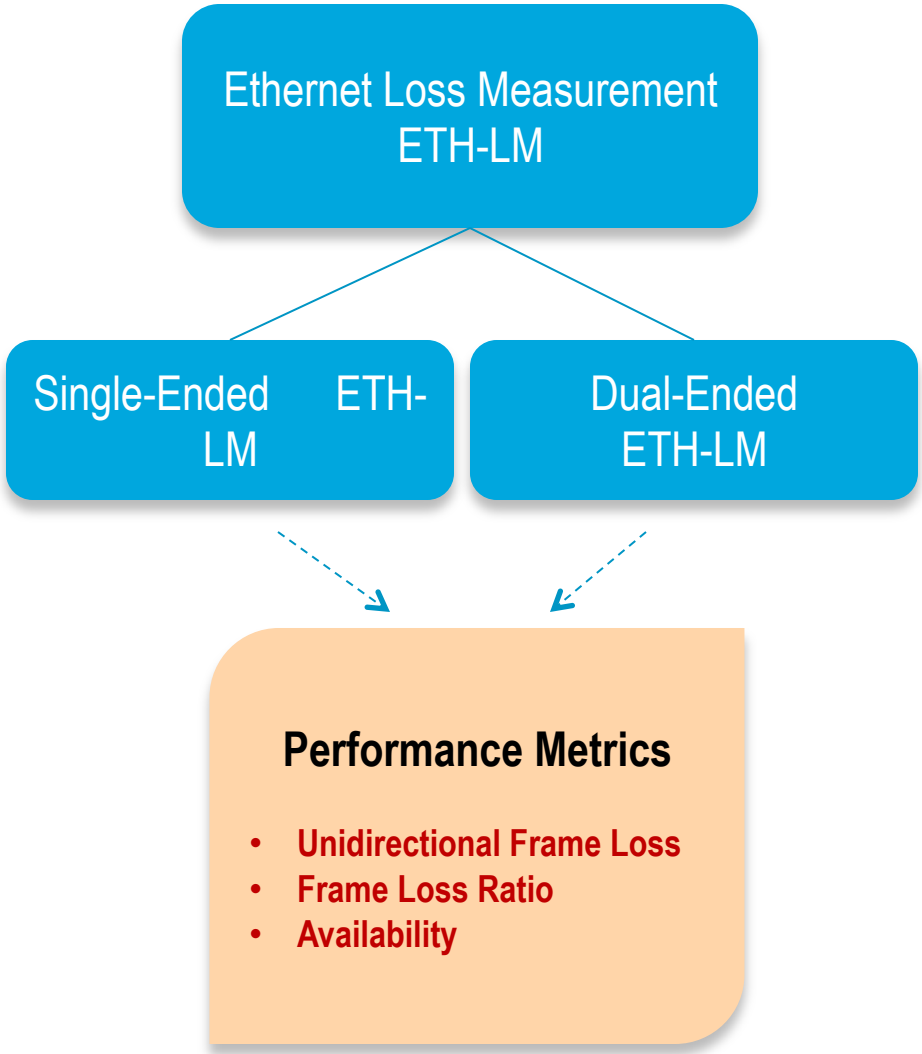
- Frame Loss calculated based on actual in-profile service counters
- Applicable to point-to-point services only (with ETH-LM)
- Near-End Frame Loss measurement

  Loss associated with Ingress Data Frame
- Far-End Frame Loss measurement

  Loss associated with Egress Data Frame
- Per-CoS counters maintained per MEP

  TxFCl – in-profile data frames transmitted towards the peer MEP

  RxFCl – in-profile data frames received from the peer MEP



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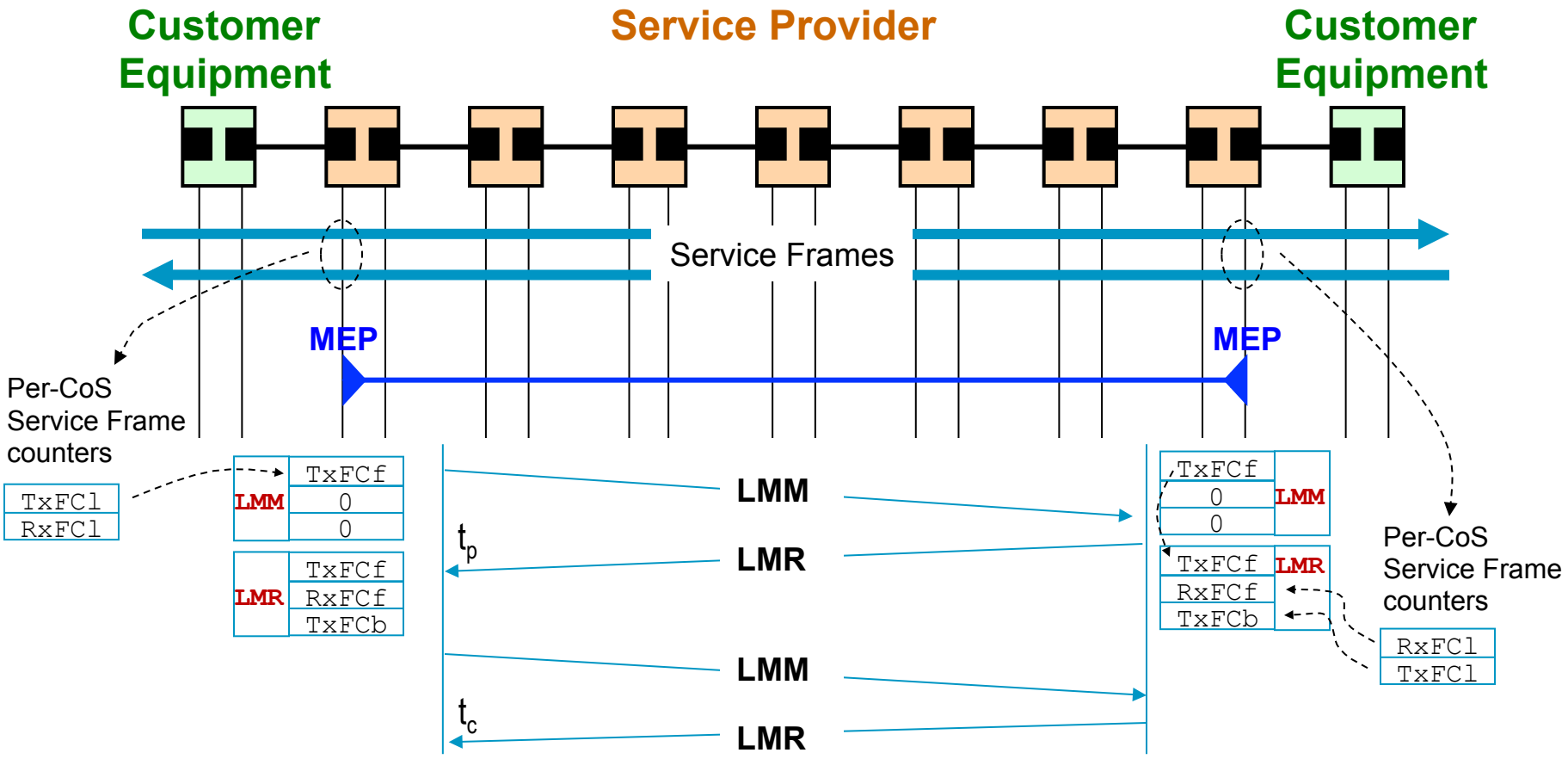
ITU-T Y.1731 Overview

Single-Ended (On-demand) ETH-LM



Frame Loss (Far-end)

$(TxFCf[t_c] - TxFCf[t_p]) - (RxFCf[t_c] - RxFCf[t_p])$

Frame Loss (Near-end)

$(TxFCb[t_c] - TxFCb[t_p]) - (RxFCl[t_c] - RxFCl[t_p])$

t_p – Time Previous
t_c – Time Current

LMM – Loss Measurement Message
LMR – Loss Measurement Reply

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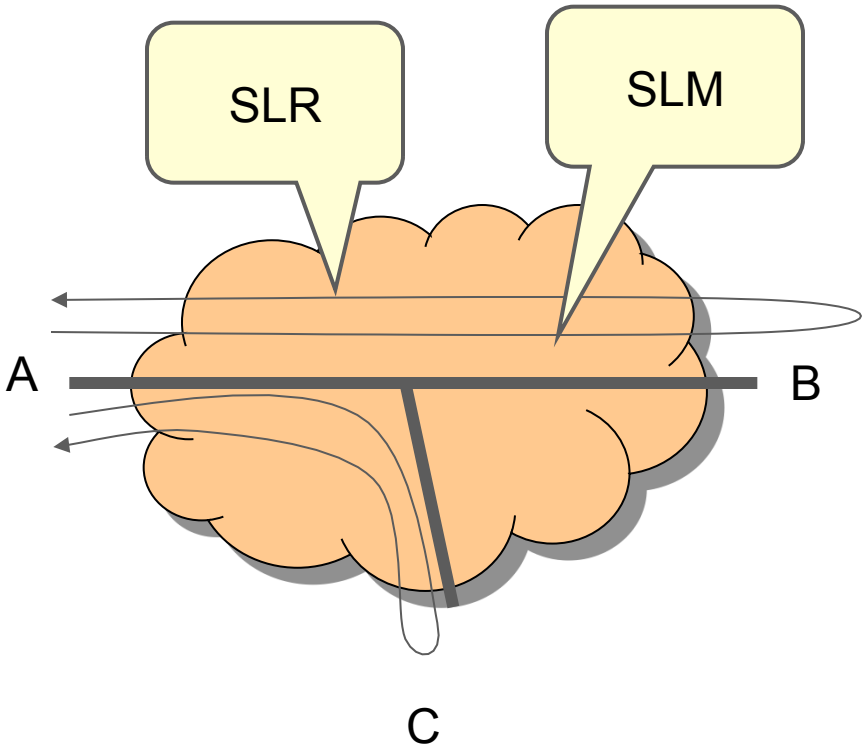
Synthetic Loss Measurement (ETH-SLM)

- Y.1731 ETH-LM cannot be used for frame loss in multipoint EVCs
- A new protocol (SLM) based on synthetic frames
  - Statistical Frame Loss
  - Covers P2P or MP EVCs
  - Implementable by ALL platforms
- ITU agreed (June 2010) to allocate code points for new PDUs (SLM / SLR)
- ETH-SLM included ITU-T G. 8013 / Y.1731 (07/2011)



SLM – Synthetic Loss Message
SLR – Synthetic Loss Reply

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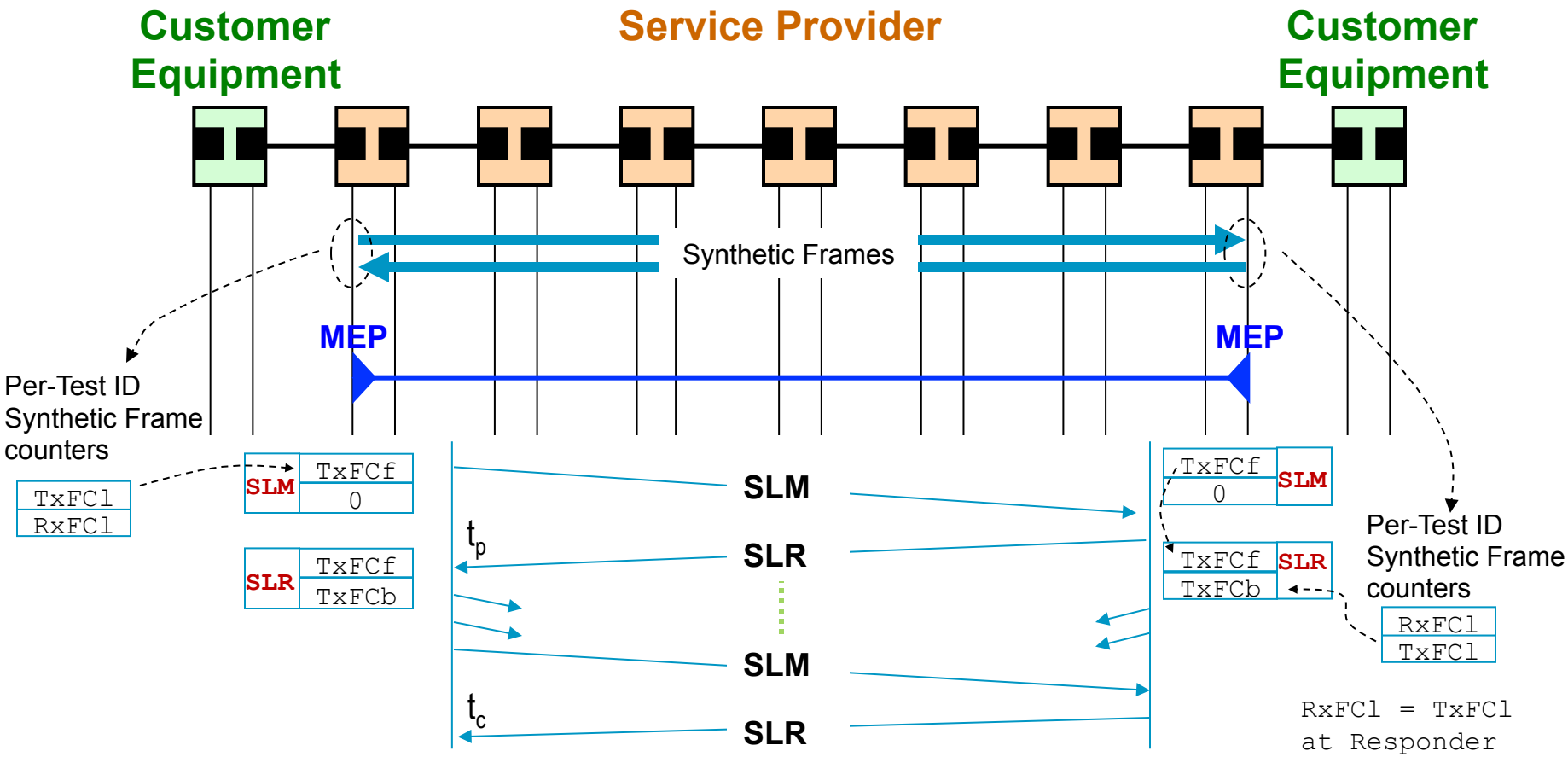
ITU-T Y.1731 Overview

Single-Ended ETH-SLM



Frame Loss (Far-end)

$(TxFCf[t_c] - TxFCf[t_p]) - (TxFCb[t_c] - TxFCb[t_p])$

Frame Loss (Near-end)

$(TxFCb[t_c] - TxFCb[t_p]) - (RxFCl[t_c] - RxFCl[t_p])$

t_p – Time Previous – Start of Measurement Period
t_c – Time Current – End of Measurement Period

SLM – Synthetic Loss Message
SLR – Synthetic Loss Reply

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Ethernet Local Management Interface (E-LMI) Overview

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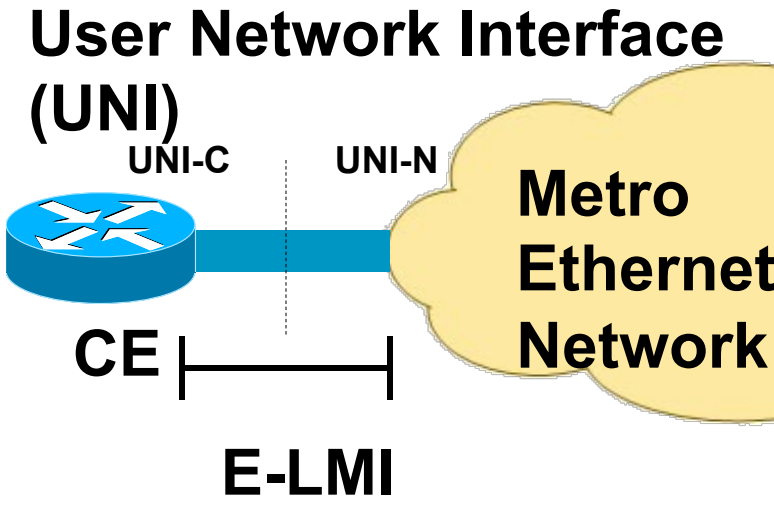
Ethernet LMI
Overview

- 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 count, 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



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Ethernet Service Activation

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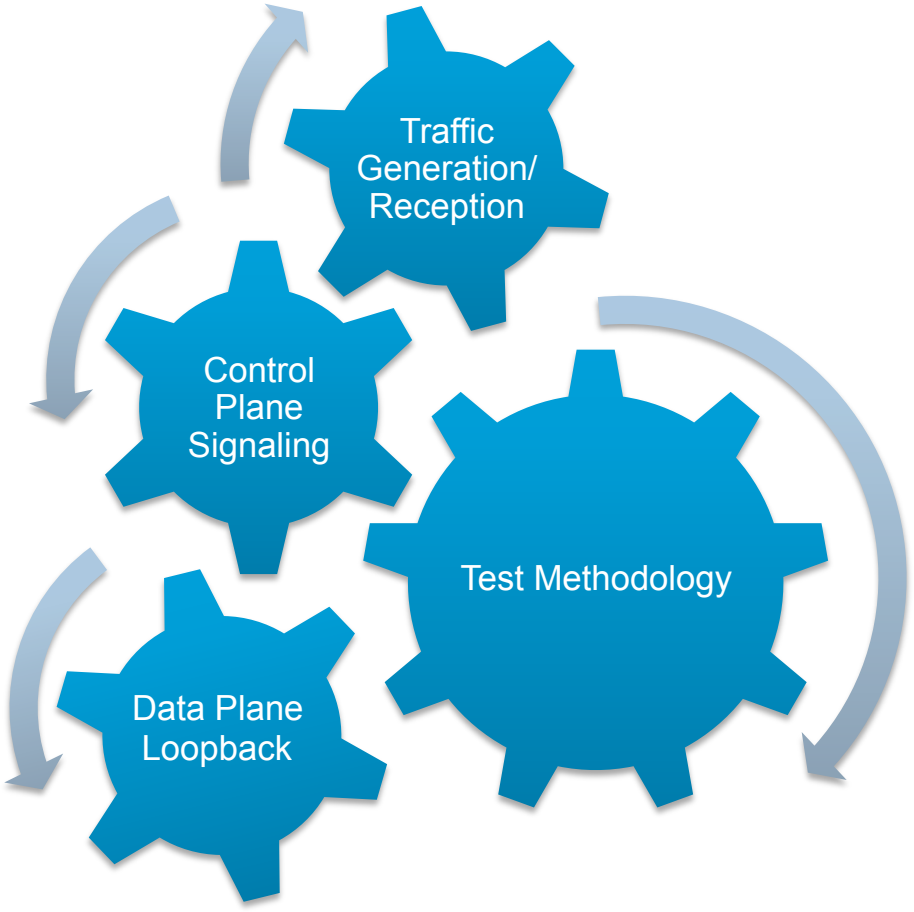
Service Activation Testing (SAT)

- Issuance of ‘Birth Certificate’
- Validation of Service Configuration
- Validation of SLA
  - Throughput
  - Latency
  - Loss
  - Jitter



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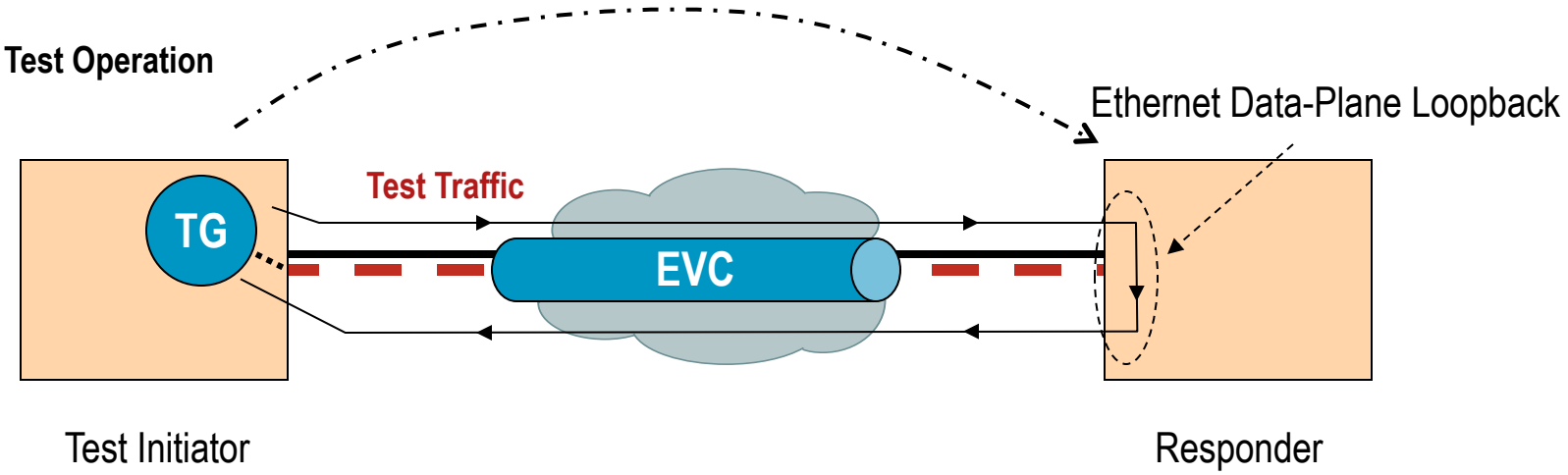
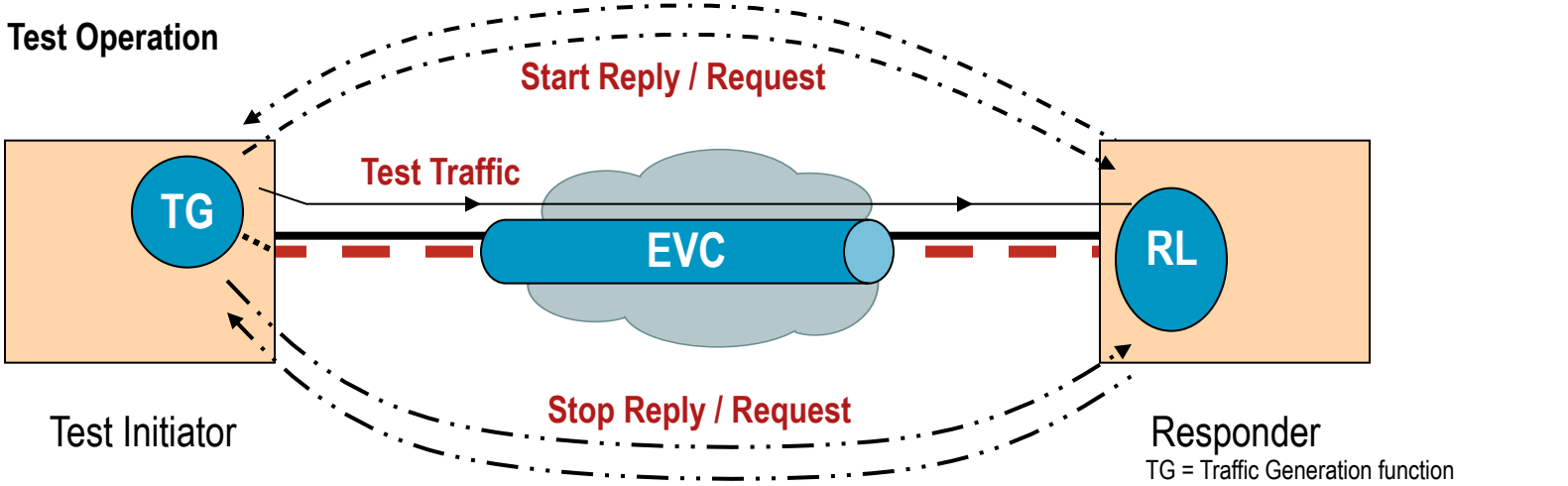
SAT Concepts

Bi-directional Test Operation



Uni-directional Test Operation



TG = Traffic Generation function
HW-accelarated (Platform-Dependent)
RL=Responder Logic

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MEF Projects

Project Name	Highlights	Status
Service Activation Testing project	• Defines set of tests needed to run before handing off a service to subscriber • Leverages ITU-T Y.1564	Approved Project Editor: CableLabs Targeting completion in **Q2, 2013**
SAT PDU project	•Defines the test PDUs that can be used to perform the tests defined by the SAT project •Defines control protocol to be used for unidirectional tests - to set up the collector and/or responder at the remote end.	Approved Project Editor: Verizon Targeting completion in **Q4, 2013**
Latching loopback project	•Defines control protocol to be used for bidirectional tests - to put remote device into latching loopback	Approved Project Editor: Adtran Targeting completion in **Q1, 2014**

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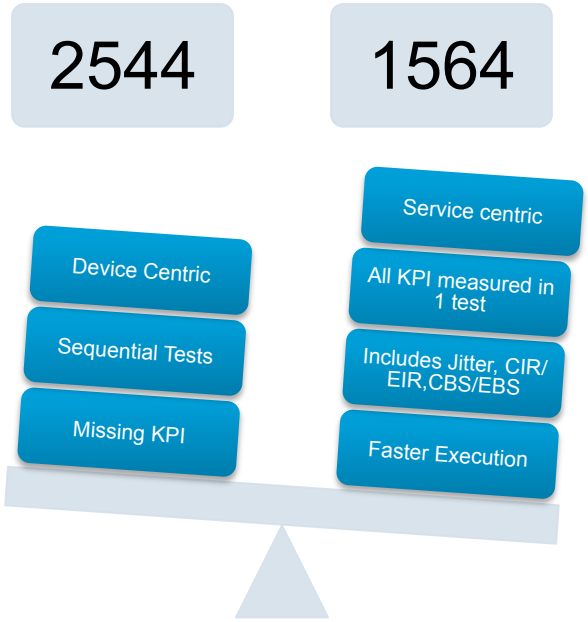
ITU-T Y.1564

- RFC2544 methodology shortcomings (as stated by Y.1564)
  - Not Ethernet service aware
  - Tests run as a single flow at a time
  - Tests are performed sequentially
  - Does not measure Frame Delay Variation
  - Does not verify CIR, CBS, EIR, EBS and CM
- Y.1564 advantages
  - Tests all KPIs at same time
  - Test to CIR to verify SLA performance (FD, FDV, FLR)
  - Tests to EIR limit and just beyond to verify policing behavior (no SLA performance expected for yellow frames (above CIR and below CIR +EIR)



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Ethernet OAM Interworking

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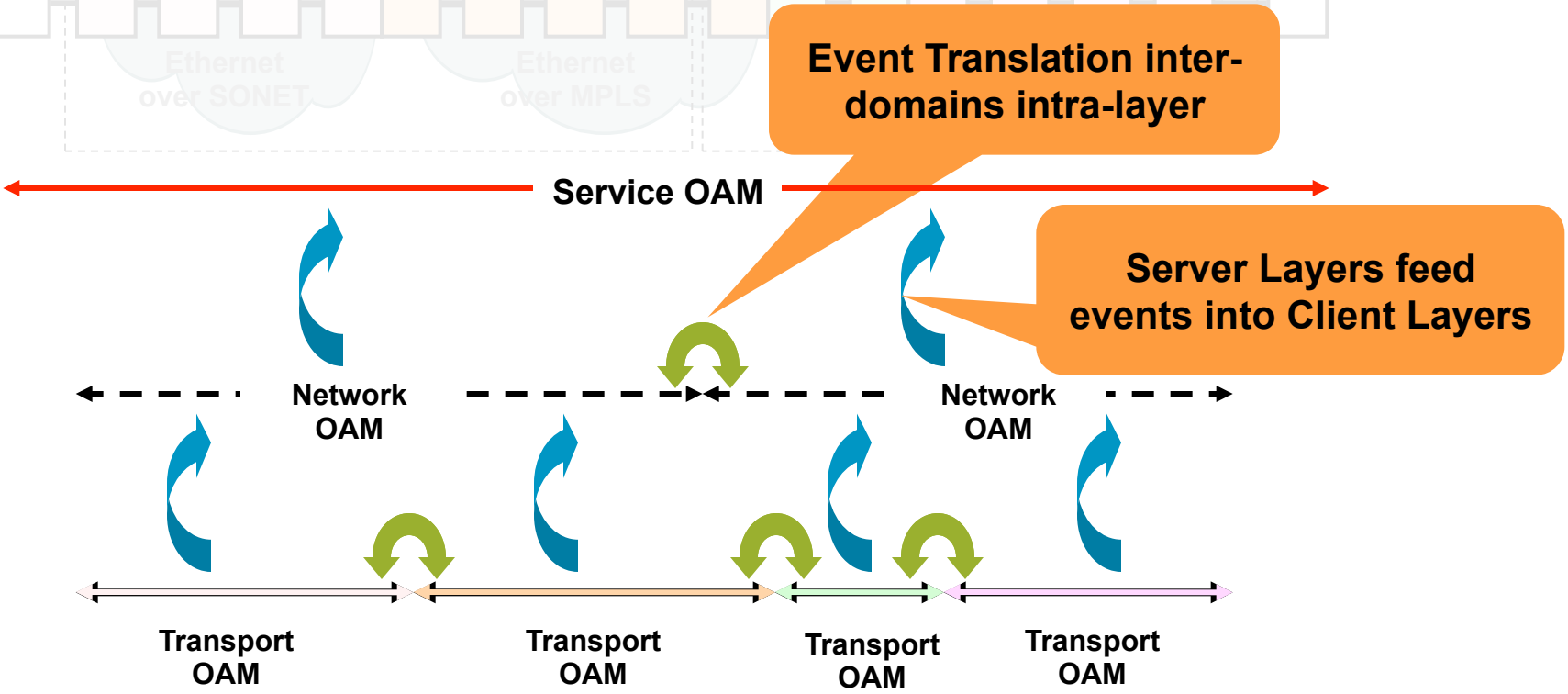
What Is OAM Interworking?

- 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



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Ethernet OAM Deployment Use Cases

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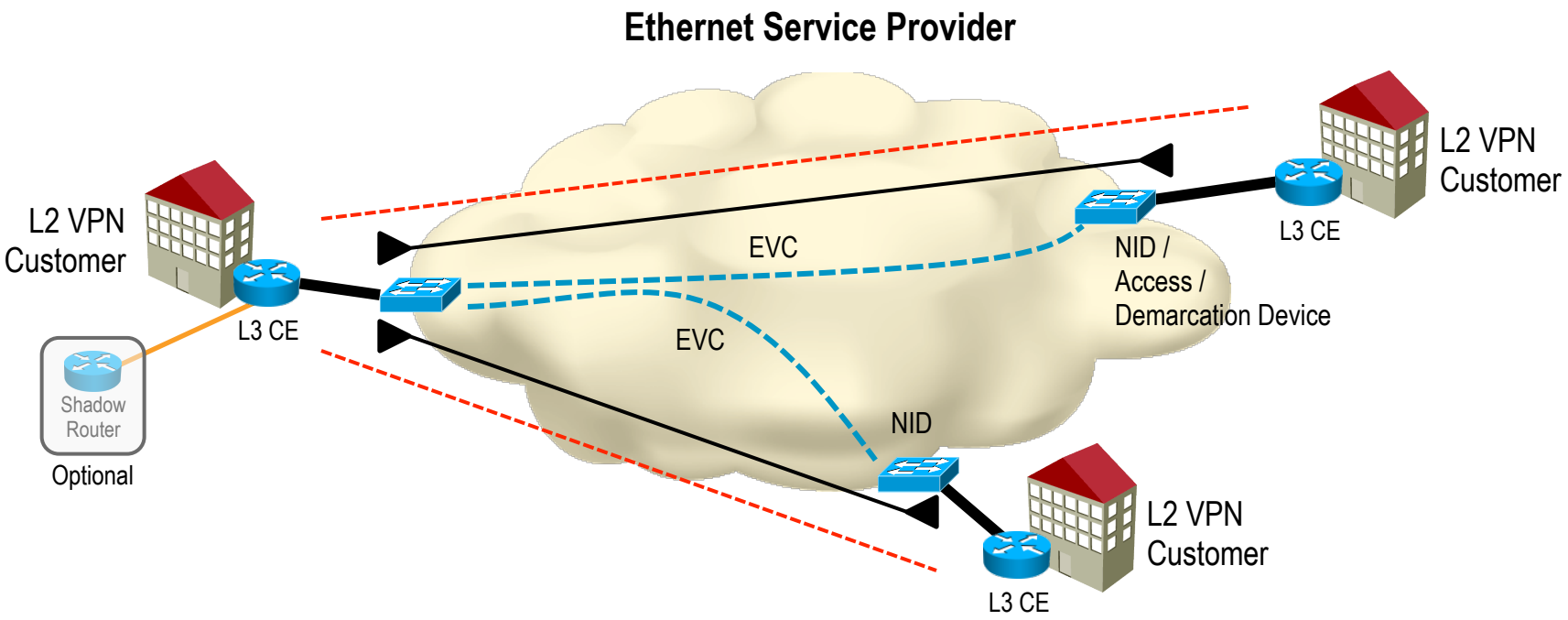
Ethernet OAM Deployment Use Case #1
Ethernet L2 VPN SLA Monitoring



EVC = Ethernet Virtual Circuit
NID = Network Interface Device
= CFM Maintenance Association End Point (MEP)
----- = IP-based probe

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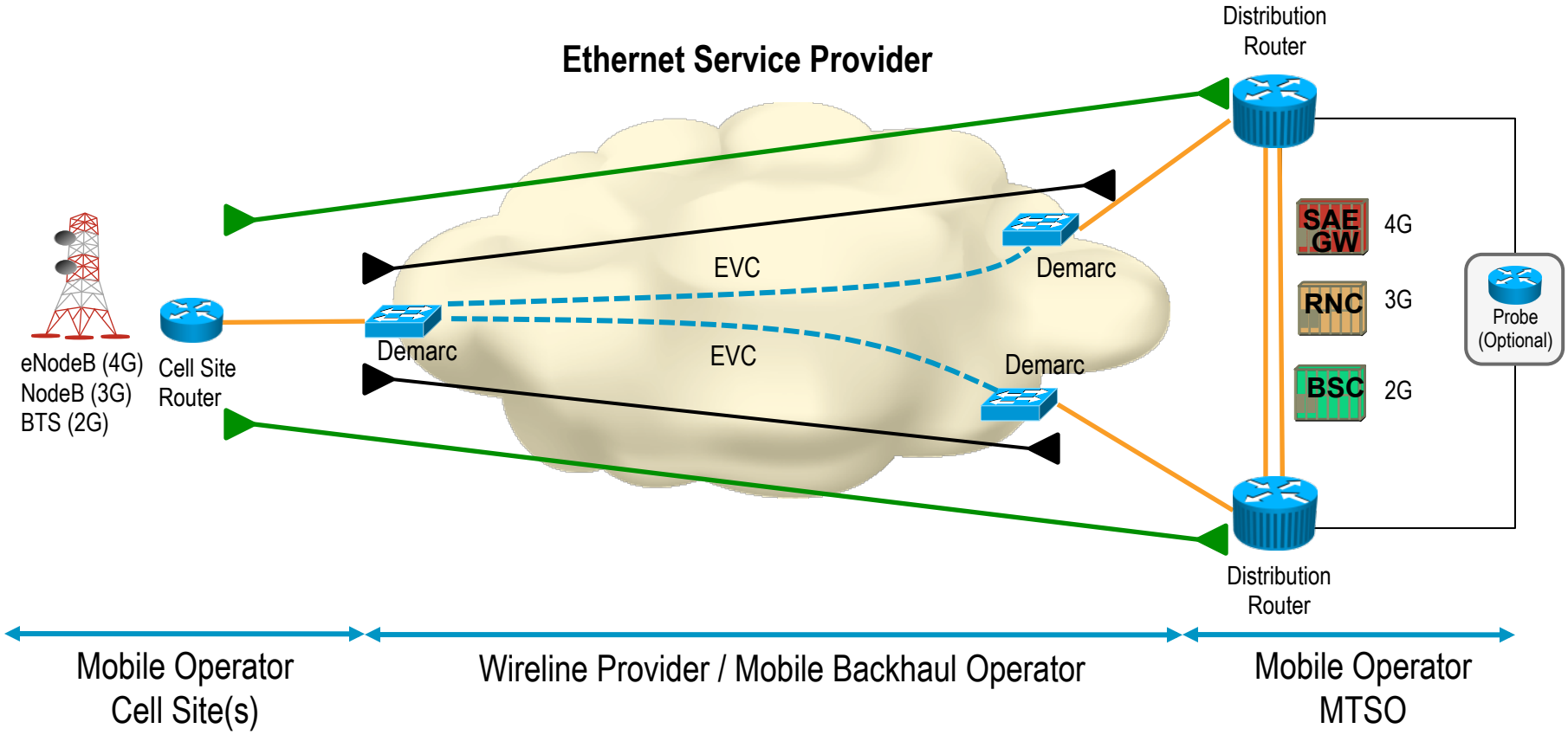
Ethernet OAM Deployment Use Case #2

Mobile Backhaul Service Monitoring



eNode B = Enhanced Node B
SAE GW = System Arch Evolution GW
RNC = Radio Network Controller

MTSO = Mobile Telephone Switching Office
BTS = Base Transceiver Station
BSC = Base Station Controller

EVC = Ethernet Virtual Circuit
NID = Network Interface De`vice
▶ = CFM Maintenance Association End Point (MEP)

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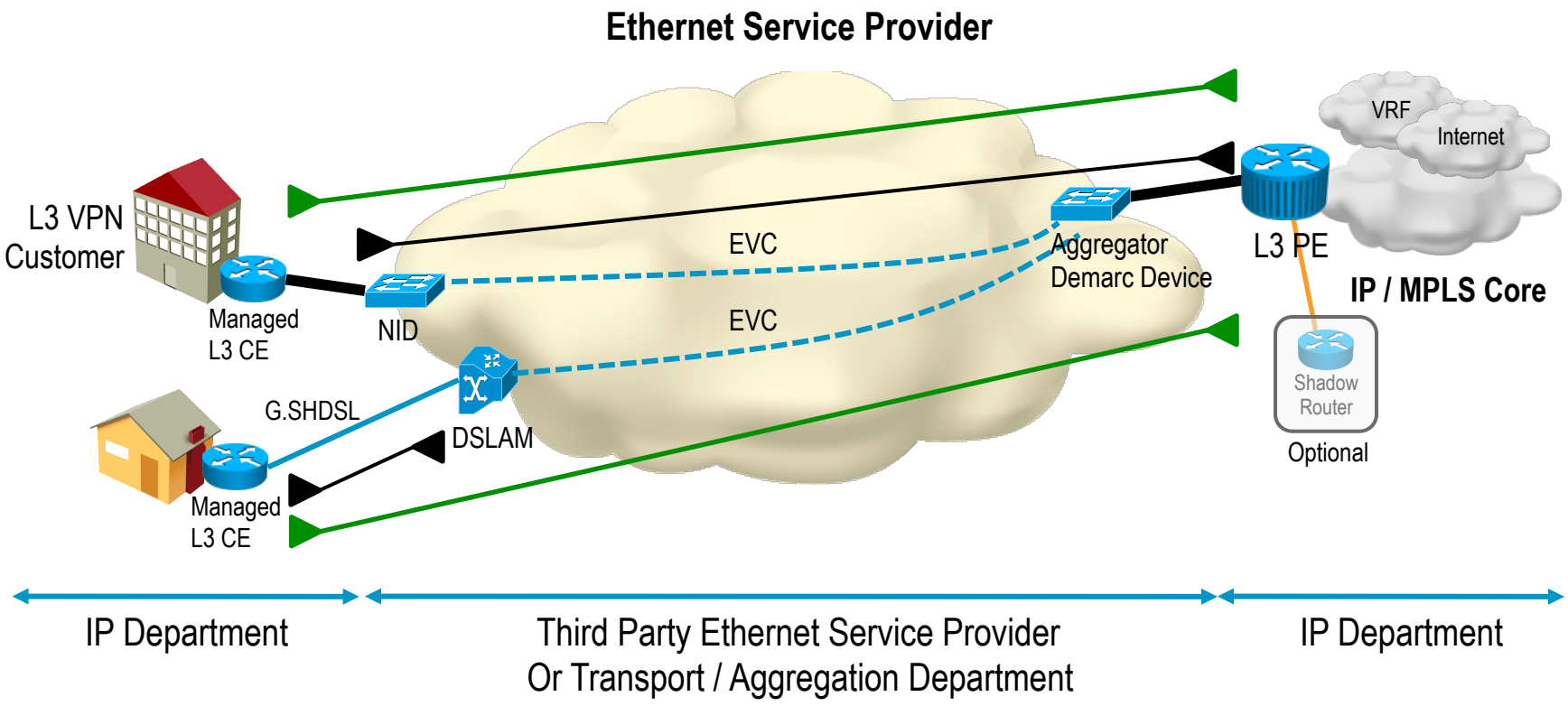
Ethernet OAM Deployment Use Case #3
Monitoring of Ethernet Access to L3VPN



EVC = Ethernet Virtual Circuit
NID = Network Interface Device
= CFM Maintenance Association End Point (MEP)
----- = IP-based probe

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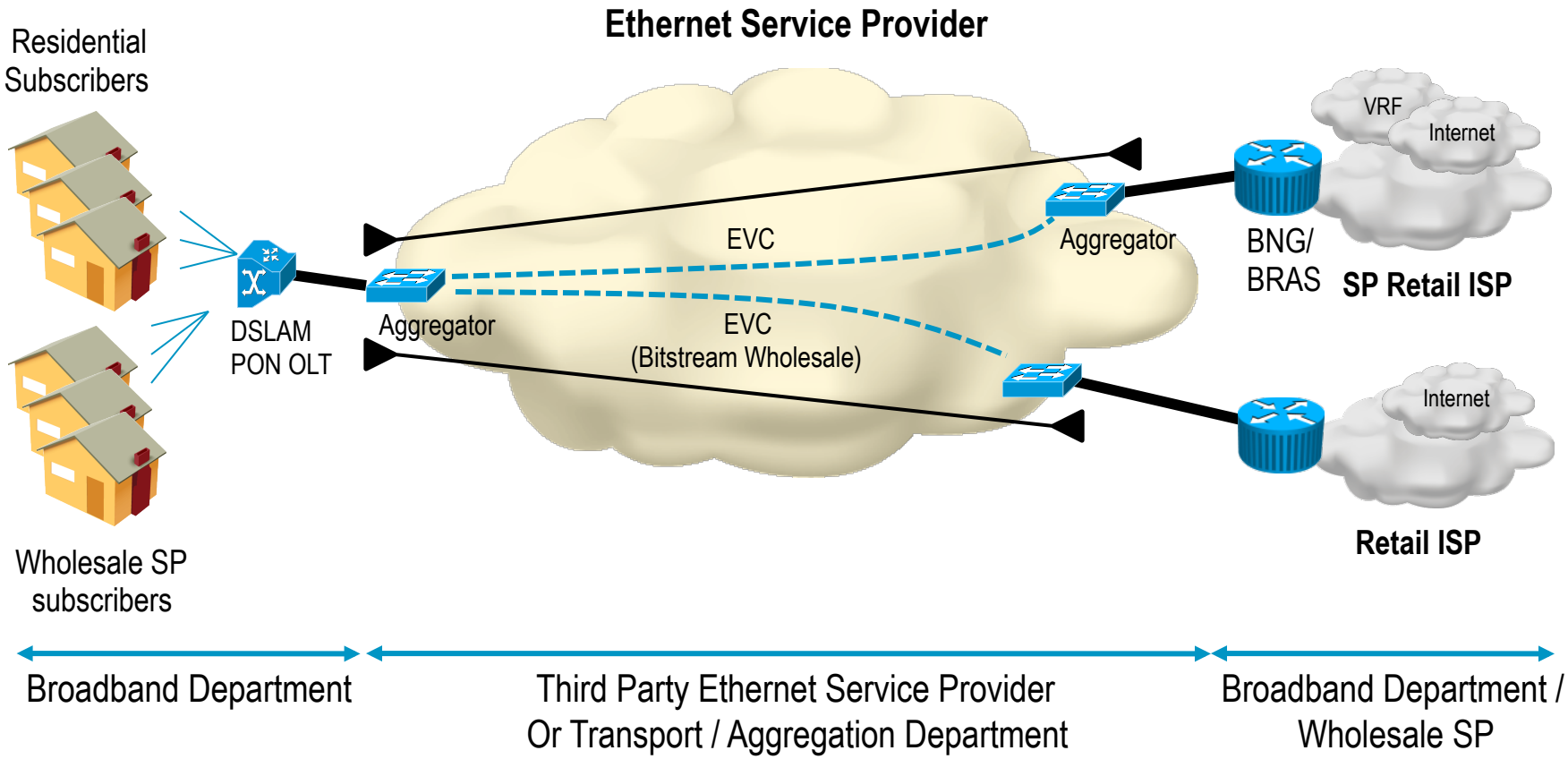
Ethernet OAM Deployment Use Case #4
Monitoring of Broadband & Wholesale Ethernet Access Service



EVC = Ethernet Virtual Circuit
NID = Network Interface Device
▶ = CFM Maintenance Association End Point (MEP)

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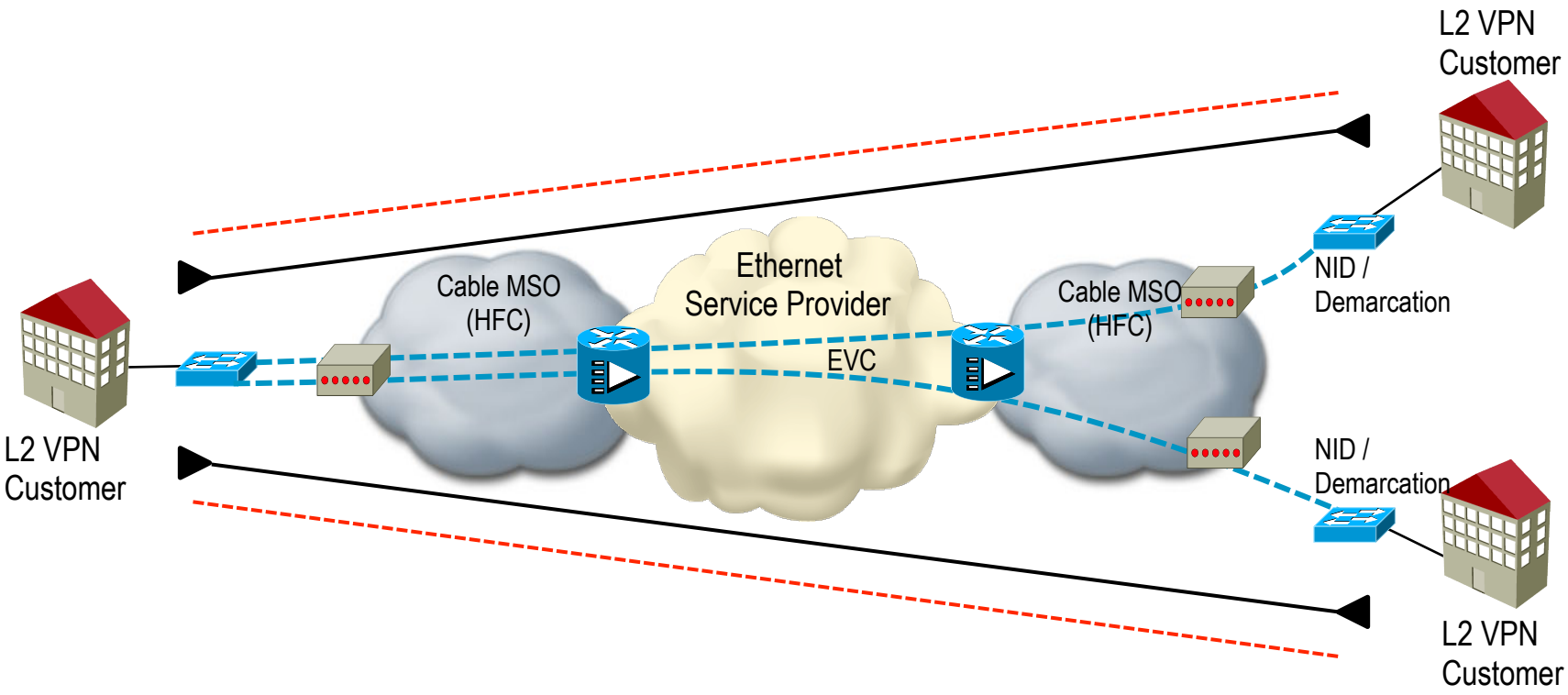
Ethernet OAM Deployment Use Case #5

Monitoring of Ethernet Service over DOCSIS Cable



EVC = Ethernet Virtual Circuit
NID = Network Interface Device
▶ = CFM Maintenance Association End Point (MEP)
----- = IP-based probe

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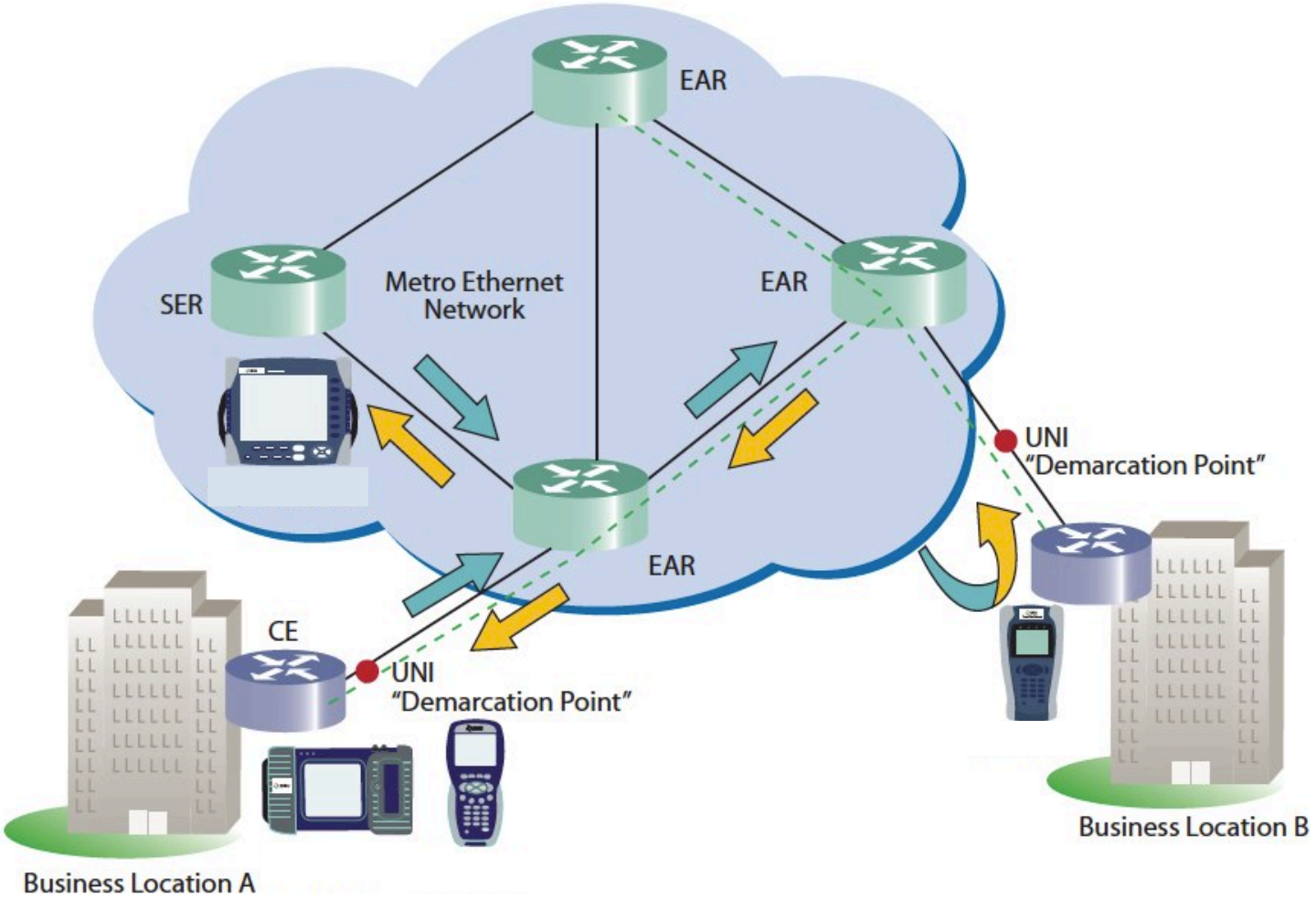
Ethernet OAM Deployment Use Case #6

Ethernet Last Mile Testing with Dataplane Loopback



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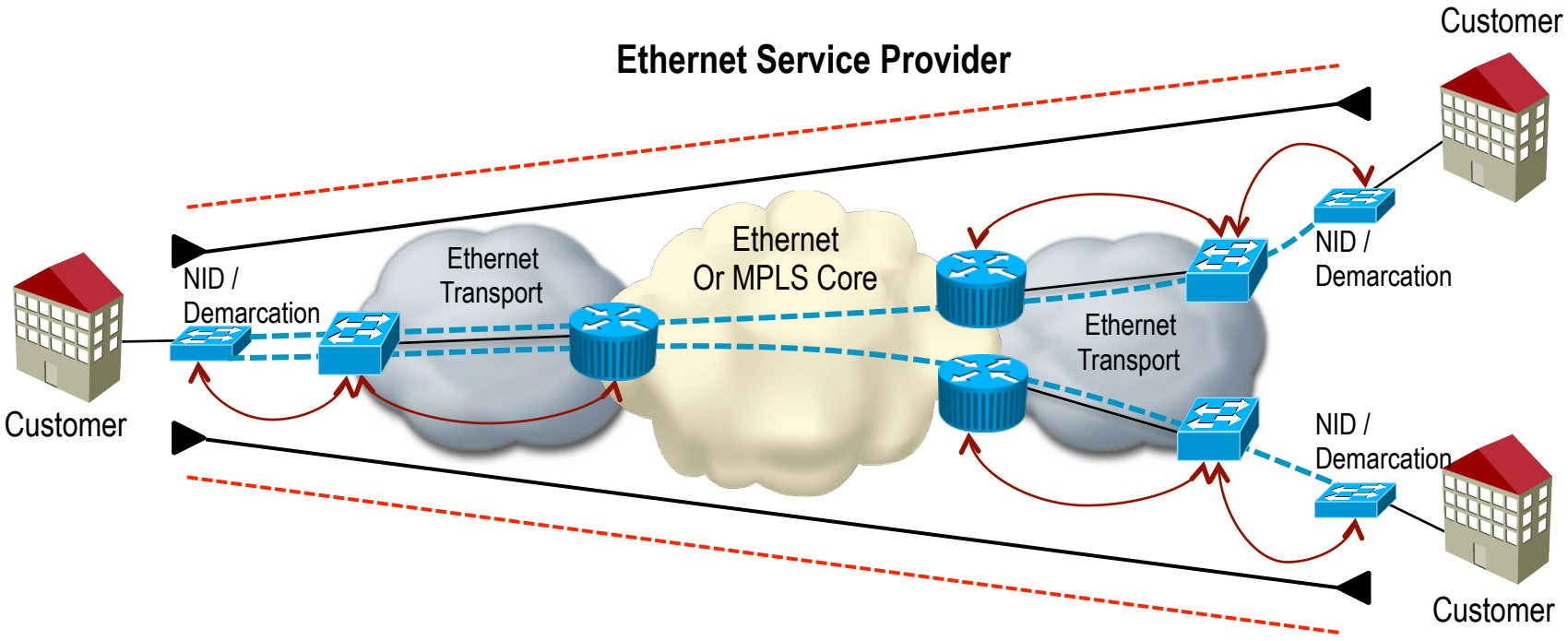
Ethernet OAM Deployment Use Case #7

Fault Management - Fault detection, Loop detection, Node monitoring, LAG port monitoring, reachability check ….



EVC = Ethernet Virtual Circuit
NID = Network Interface Device
▶ = CFM Maintenance Association End Point (MEP)
----- = IP-based probe
Link OAM Sessions

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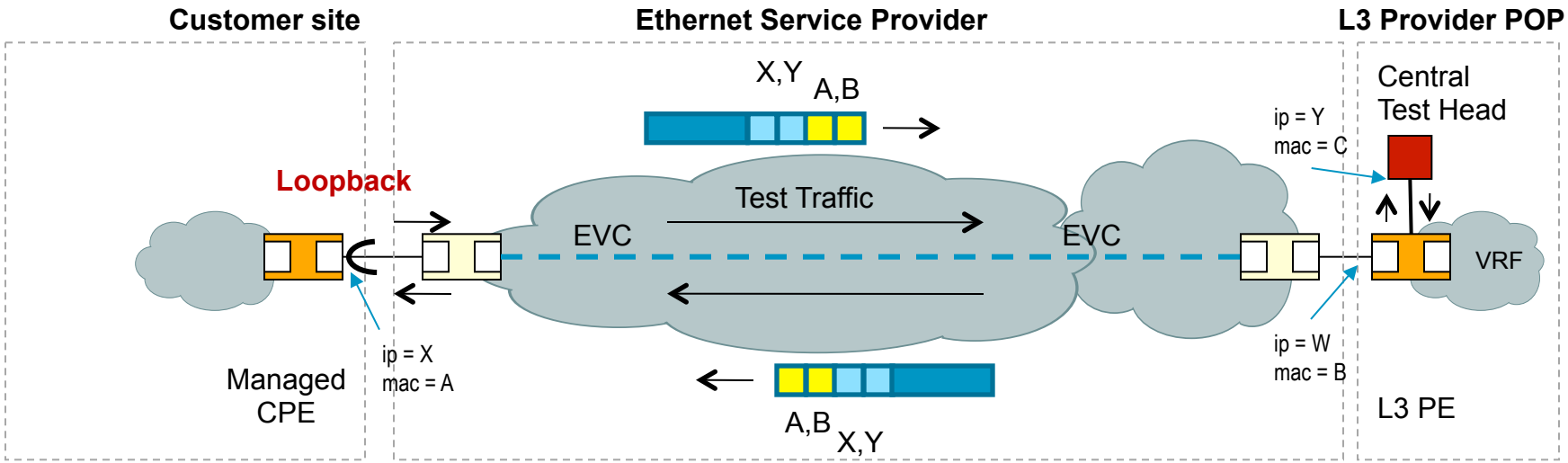
Deployment Use Case #8
Service Activation and Throughput Test with Loopback

- Application: Service Turn-Up (out-of-service)

  Throughput Test - POP-Local CPE (shown) or POP-Remote CPE



L3 Loopback

Ethernet Data-plane Loopback

- Hardware-accelerated (no CPU intervention)
- IPv4/IPv6-aware Loopback
- Configurable source IPv4/IPv6 of packets to loop
- IP address swap (implicit MAC swap)

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Fault Management Scenarios

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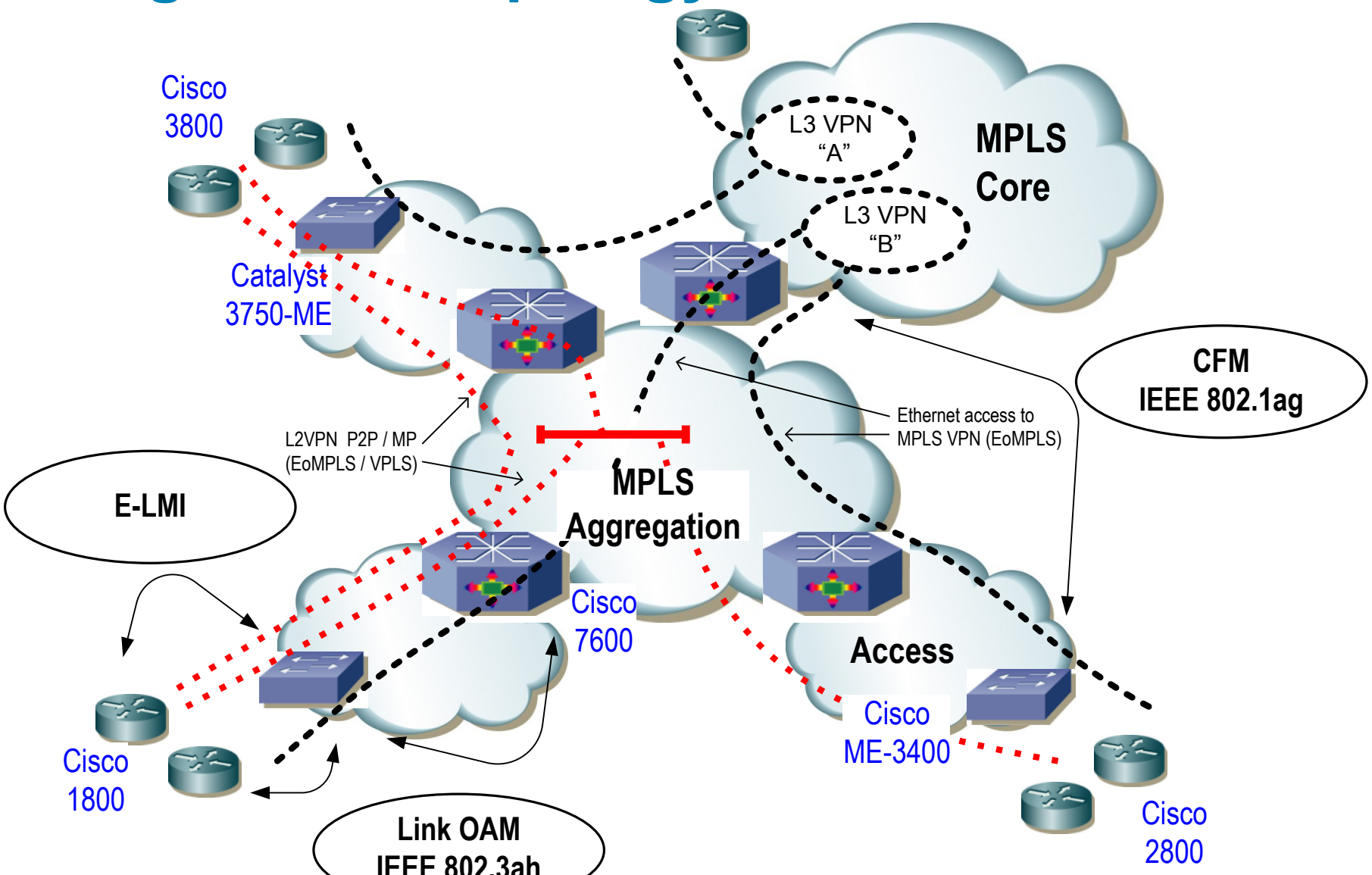
High Level Topology



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Fault Management Scenarios

Number	Description
1	End-to-End Service/Path Verification Fault Verification/Isolation
2	Using E-OAM for Ethernet Access to L3VPN
3	E2E CPE Fault Notification & CPE Corrective Action using Ethernet OAM Interworking

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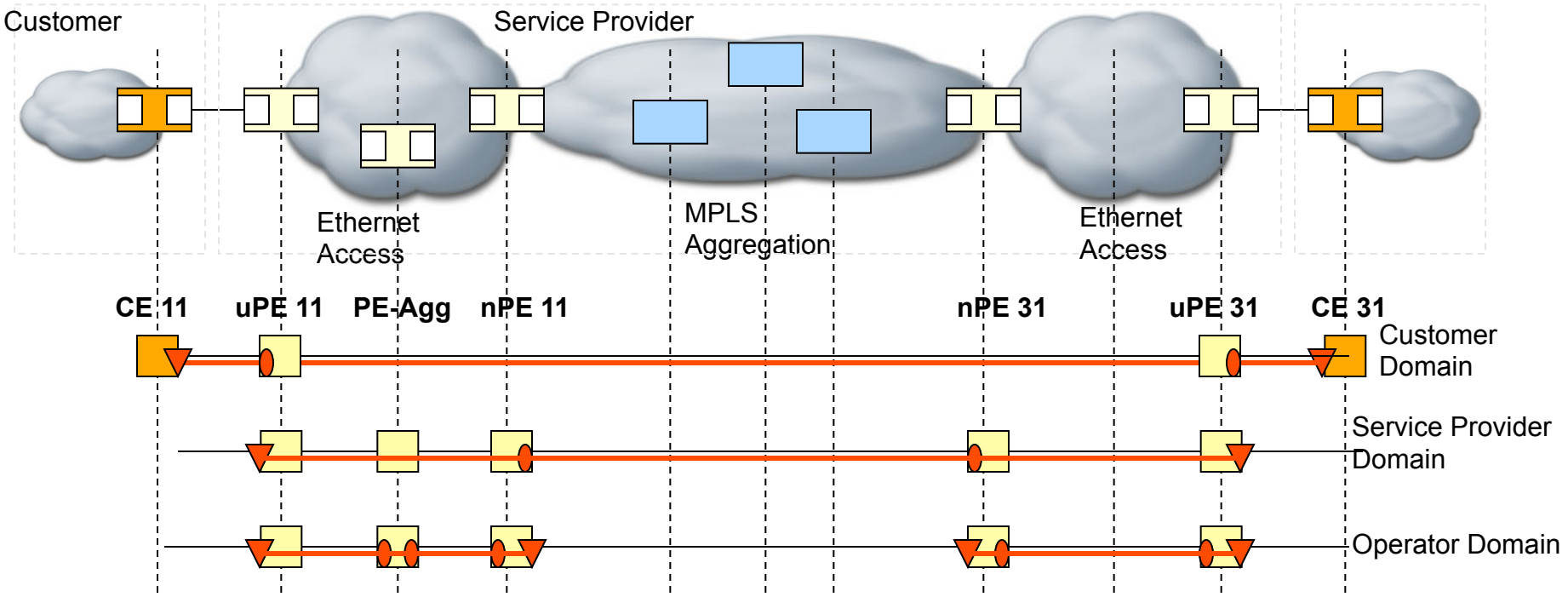
Operational Scenario 1

- Problem Statement

  Fault Verification and Fault Isolation of ethernet connectivity issues

- Problem Solution

  IEEE 802.1ag (CFM) Ping and Traceroute utilities for reactive troubleshooting of service connectivity issues



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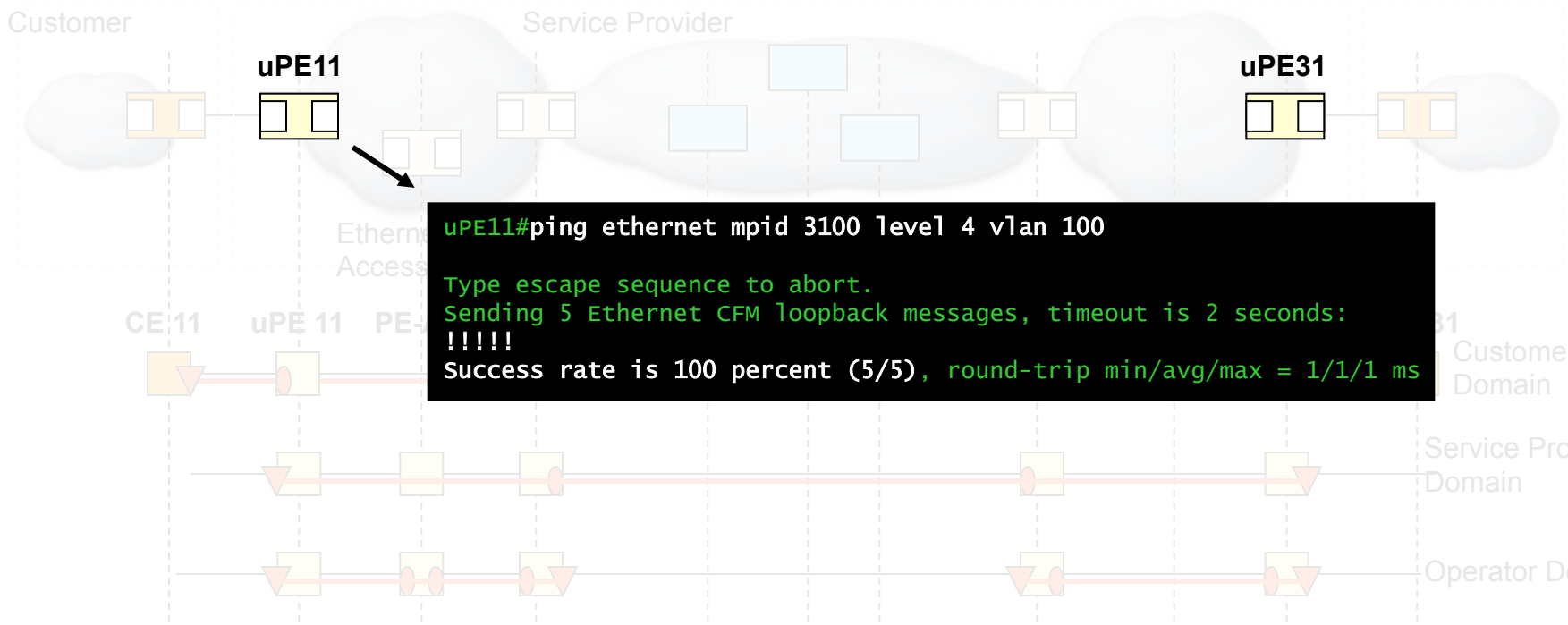
Operational Scenario 1 (cont.)

- Problem Statement

  Fault Verification and Fault Isolation of ethernet connectivity issues

- Problem Solution

  IEEE 802.1ag (CFM) Ping and Traceroute utilities for reactive troubleshooting of service connectivity issues



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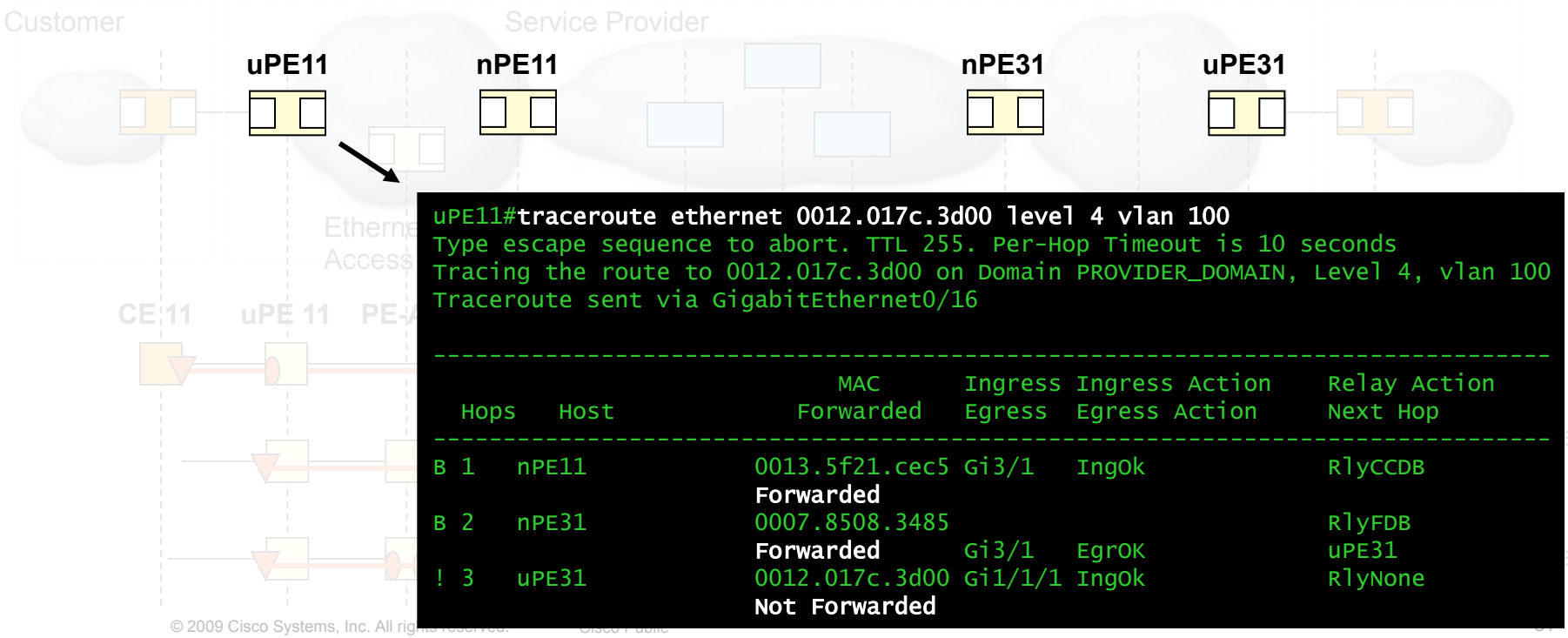
Operational Scenario 1 (cont.)

- Problem Statement

  Fault Verification and Fault Isolation of ethernet connectivity issues

- Problem Solution

  IEEE 802.1ag (CFM) Ping and Traceroute utilities for reactive troubleshooting of service connectivity issues



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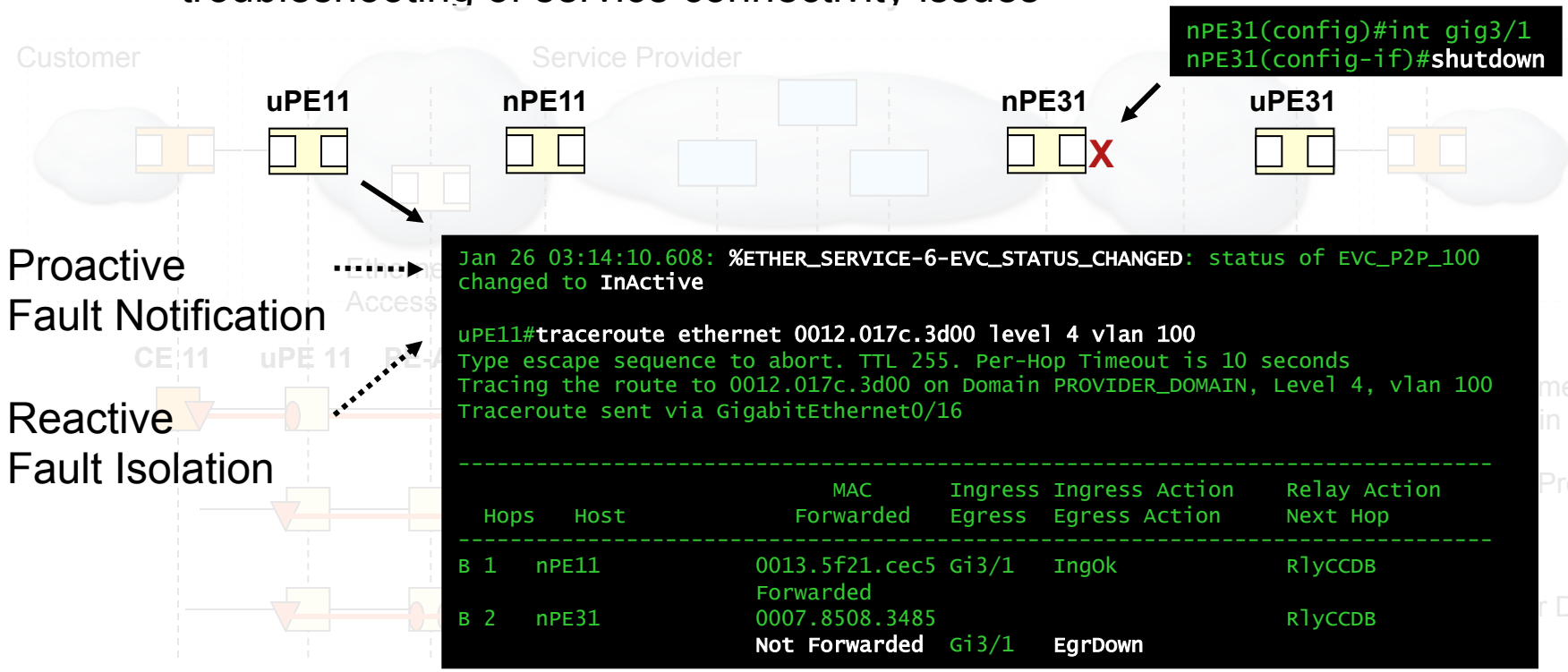
Operational Scenario 1 (cont.)

- Problem Statement

  Fault Verification and Fault Isolation of ethernet connectivity issues

- Problem Solution

  IEEE 802.1ag (CFM) Ping and Traceroute utilities for reactive troubleshooting of service connectivity issues



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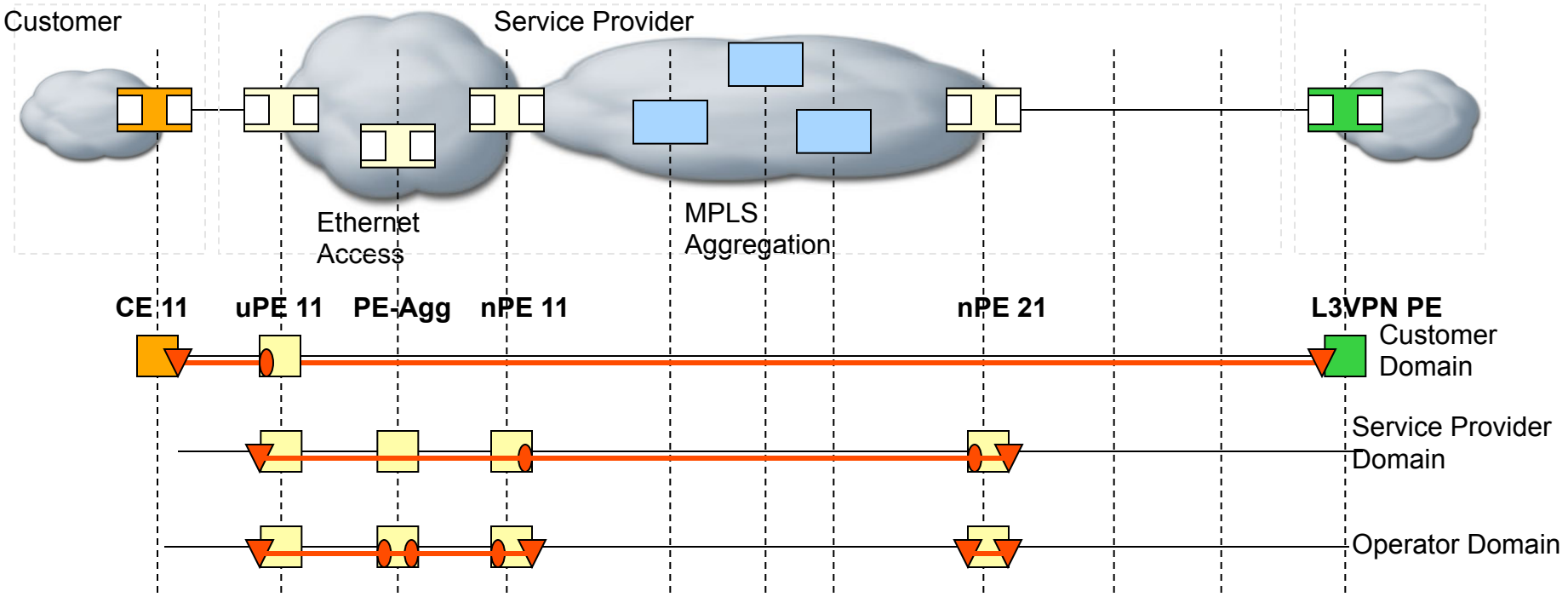
Operational Scenario 2

- Problem Statement

  Troubleshooting Ethernet access connectivity problems by L3VPN PE

- Problem Solution

  IEEE 802.1ag CFM with Outward-facing / Down MEPs at L3VPN PE



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Operational Scenario 2 (cont.)

- Problem Statement

  Troubleshooting Ethernet access connectivity problems by L3VPN PE

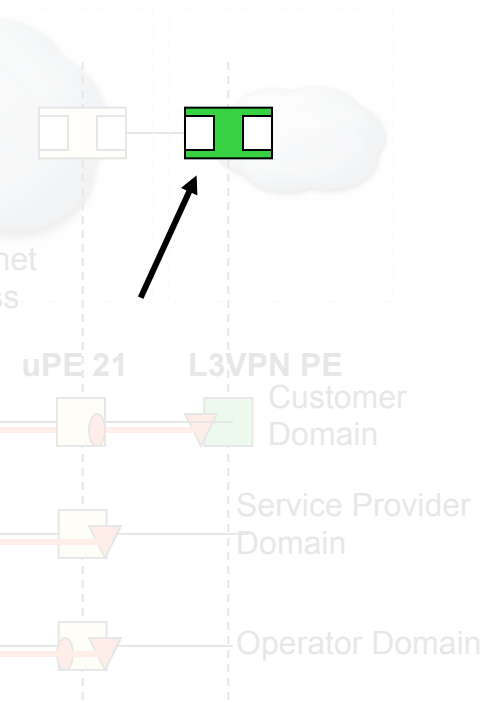
- Problem Solution

  IEEE 802.1ag CFM with Outward-facing / Down MEPs at L3VPN PE

```
L3VPN-PE#show running-config | begin GigabitEthernet3/0/0
interface GigabitEthernet3/0/0
 description L3VPN PE to nPE21 gig3/3
 ethernet cfm mep level 4 outward domain PROVIDER_DOMAIN mpid 2450 vlan 450
 ethernet cfm mep level 4 outward domain PROVIDER_DOMAIN mpid 2350 vlan 350
!
interface GigabitEthernet3/0/0.350
 description To CE31
 encapsulation dot1Q 350
 ip vrf forwarding BLUE
 ip address 1.1.1.1 255.255.255.0
!
interface GigabitEthernet3/0/0.450
 description To CE21
 encapsulation dot1Q 450
 ip vrf forwarding RED
 ip address 1.1.1.1 255.255.255.0


L3VPN-PE#show ethernet cfm maintenance-points remote
Can only Ping/Traceroute to remote MEPs marked with *

MPID  Level Mac Address    Vlan PortState InGressPort     Age(sec) Service ID
3350* 4     0012.017c.3d00 350  UP        Gi3/0/0.350     20       customer_350_provider
2451* 4     0019.552c.0b80 450  UP        Gi3/0/0.450     23       customer_450_provider
```



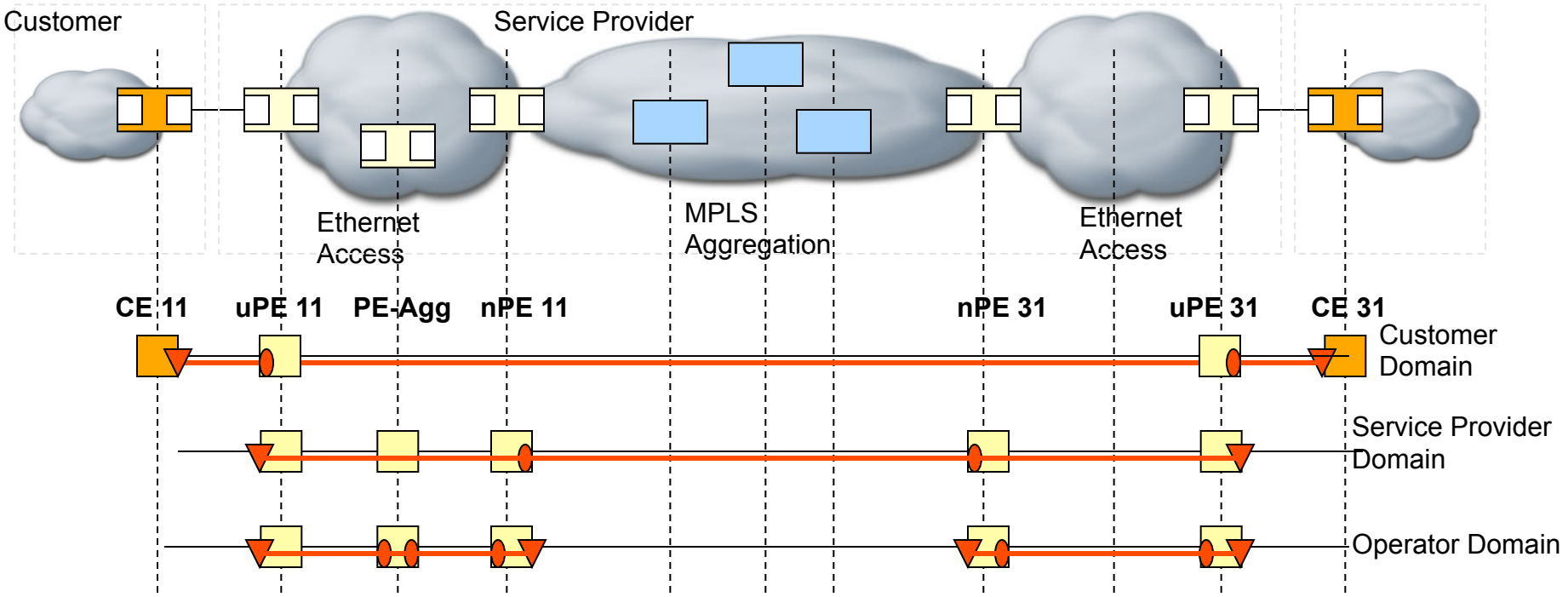
Operational Scenario 3

- Problem Statement

  End to End Fault Notification of service status to Customer Equipment

- Problem Solution

  IEEE 802.3ah to IEEE 802.1ag (CFM) Inter-Working (IW) for propagation of EVC status and CFM to E-LMI IW for notification to CE



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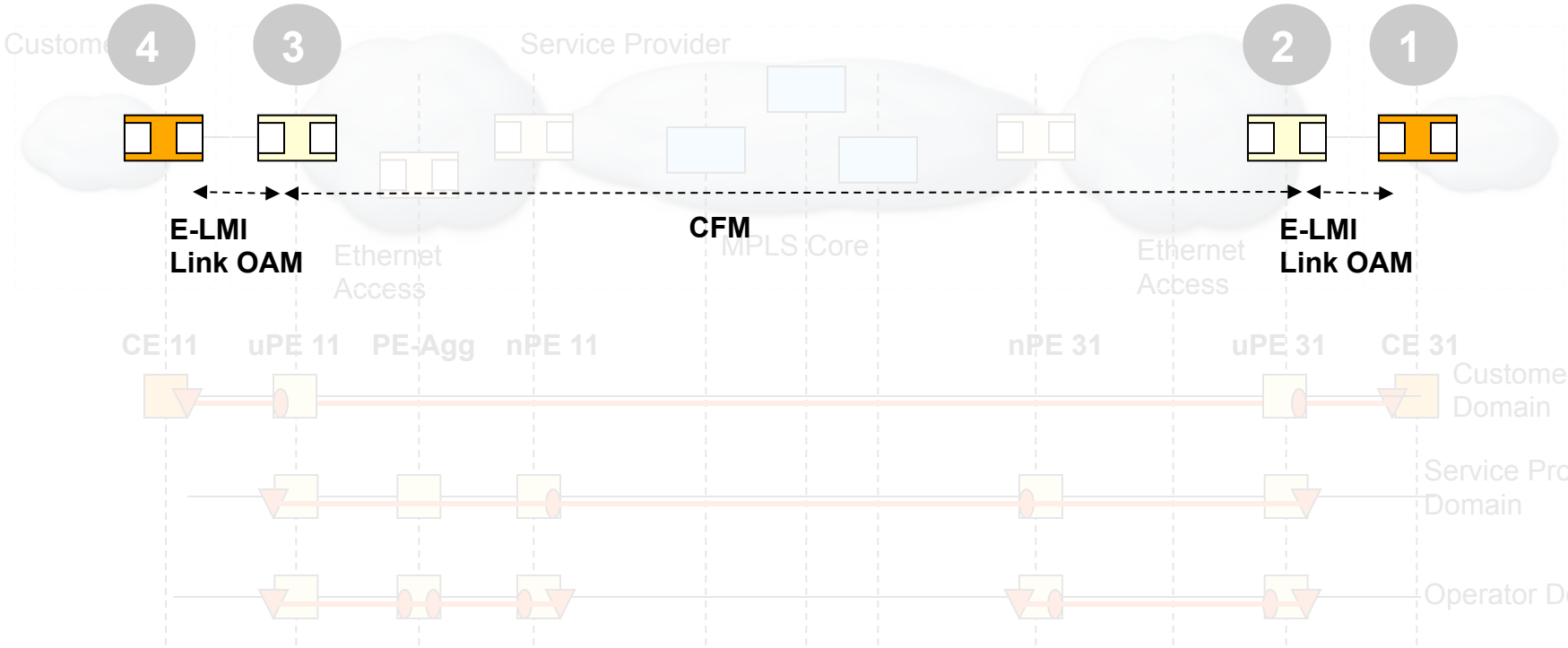
Operational Scenario 3 (cont.)

- Problem Statement

  End to End Fault Notification of service status to Customer Equipment

- Problem Solution

  IEEE 802.3ah to IEEE 802.1ag (CFM) Inter-Working (IW) for propagation of EVC status and CFM to E-LMI IW for notification to CE



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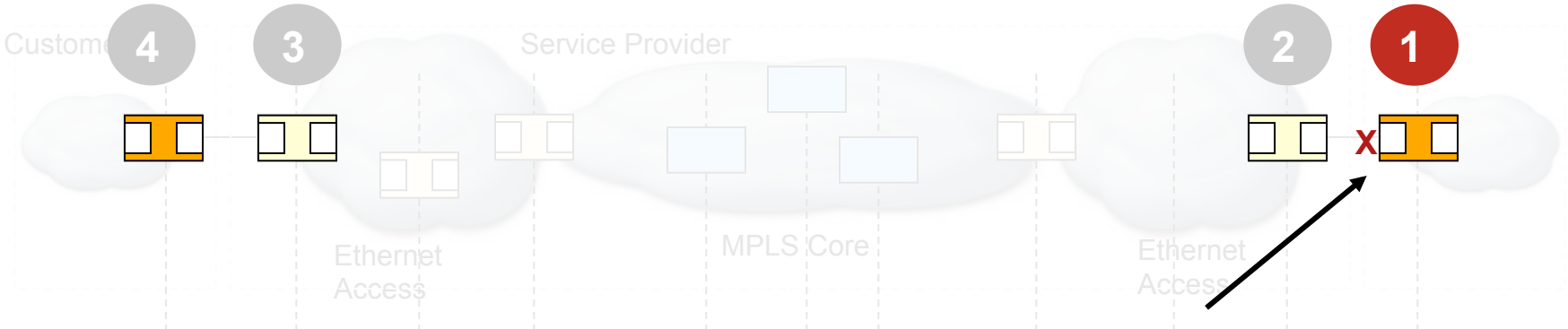
Operational Scenario 3 (cont.)

- Problem Statement

  End to End Fault Notification of service status to Customer Equipment

- Problem Solution

  IEEE 802.3ah to IEEE 802.1ag (CFM) Inter-Working (IW) for propagation of EVC status and CFM to E-LMI IW for notification to CE




```
CE31(config)#int fast 0/0
CE31(config-if)#shutdown

Jan 26 03:40:08.176: %ETHERNET_OAM-6-EXIT_SESSION: The client on interface Fa0/0
has left the OAM session.
Jan 26 03:40:10.180: %LINK-5-CHANGED: Interface FastEthernet0/0, changed state to
administratively down
Jan 26 03:40:11.180: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to down
```

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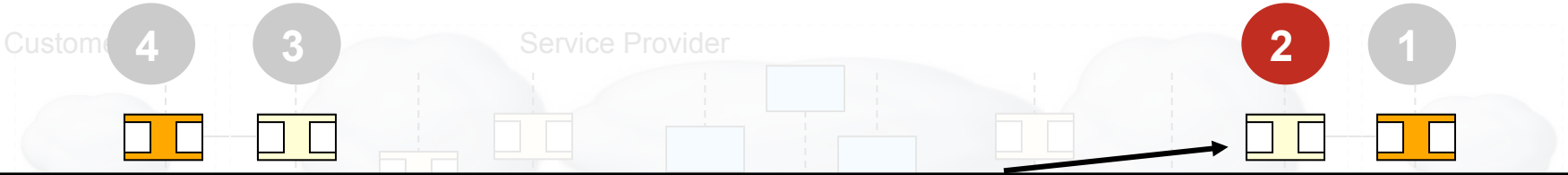
Operational Scenario 3 (cont.)

- Problem Statement

  End to End Fault Notification of service status to Customer Equipment

- Problem Solution

  IEEE 802.3ah to IEEE 802.1ag (CFM) Inter-Working (IW) for propagation of EVC status and CFM to E-LMI IW for notification to CE




```
Jan 26 03:40:08.176: %ETHERNET_OAM-6-RFI: The client on interface Fa1/0/1 has received a remote failure
Indication from its remote peer (failure reason = remote client administratively turned off)

Jan 26 03:40:08.184: %ETHER_SERVICE-6-EVC_STATUS_CHANGED: status of EVC_P2P_100 changed to InActive
Jan 26 03:40:09.191: %ETHERNET_OAM-6-EXIT_SESSION: The client on interface Fa1/0/1 has left the OAM session.

uPE31#show ethernet service evc
Identifier                     Type  Act-UNI-cnt Status
EVC_P2P_100                    P-P       1       InActive

uPE31#show ethernet lmi evc
UNI Id: CE31_UNI
St  Evc Id                                  CE-VLAN
--- --------------------------------------- ---------------------------------
 ?I EVC_P2P_100                             100

Key: St=Status, A=Active, P=Partially Active, I=Inactive, *=Default EVC, ?=Link Down
```

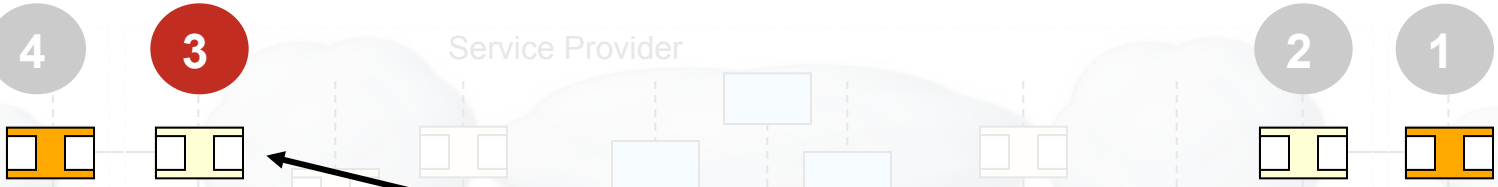
Operational Scenario 3 (cont.)

- Problem Statement

  End to End Fault Notification of service status to Customer Equipment

- Problem Solution

  IEEE 802.3ah to IEEE 802.1ag (CFM) Inter-Working (IW) for propagation of EVC status and CFM to E-LMI IW for notification to CE




```
Jan 26 03:40:36.093: %ETHER_SERVICE-6-EVC_STATUS_CHANGED: status of EVC_P2P_100 changed to InActive

uPE11#show ethernet cfm maintenance-point remote
MPID Level Mac Address    Vlan PortState InGressPort     Age(sec) Service ID
3100 4     0012.017c.3d00 100  DOWN      Gi0/16          21       customer_100_provider

uPE11#show ethernet service evc
Identifier                     Type  Act-UNI-cnt Status
EVC_P2P_100                    P-P       1       InActive

uPE11#show ethernet lmi evc
UNI Id: CE11_UNI
St  Evc Id                                 CE-VLAN
--- ------------------------------------- ---------------------------------
  I EVC_P2P_100                            100

Key: St=Status, A=Active, P=Partially Active, I=Inactive, *=Default EVC, ?=Link Down
```

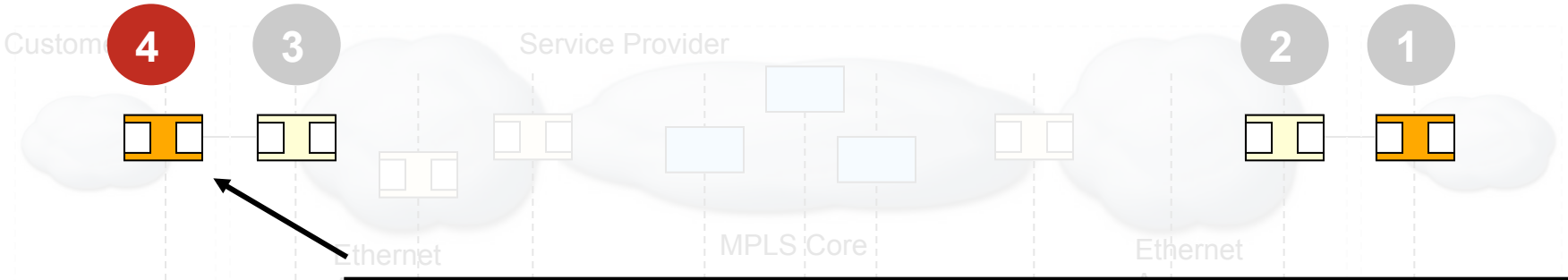
Operational Scenario 3 (cont.)

- Problem Statement

  End to End Fault Notification of service status to Customer Equipment

- Problem Solution

  IEEE 802.3ah to IEEE 802.1ag (CFM) Inter-Working (IW) for propagation of EVC status and CFM to E-LMI IW for notification to CE



Proactive E2E Fault Notification

Proactive CPE Action

```
CE11#show ethernet lmi evc
UNI Id: CE11_UNI
St  Evc Id                                  CE-VLAN
--- --------------------------------------- --------------------------------
  I EVC_P2P_100                             100

Key: St=Status, A=Active, P=Partially Active, I=Inactive, *=Default EVC, ?=Link Down

CE11#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
<snip>
GigabitEthernet0/0.100     100.100.100.11  YES manual down                  down
```

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Summary

- You can perform fault, performance and configuration management with E-OAM for Ethernet based Services
- There are multiple suites of protocols from various standard bodies (& vendors) that work in different bucket
- And they do interwork to give you a comprehensive troubleshooting and maintenance platform.

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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

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