Network and Service Interworking in Layer 2 VPNs over MPLS

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ALCATEL

Outline

- Motivation for Converging L2 Services on MPLS
- Network and Service Interworking
- Expectations on the New Converged Packet Network
- Interworking the User Plane
- Interworking the Control Plane
- Interworking the Management Plane (OAM)
- Conclusions
- Further Reading

Service Convergence over MPLS

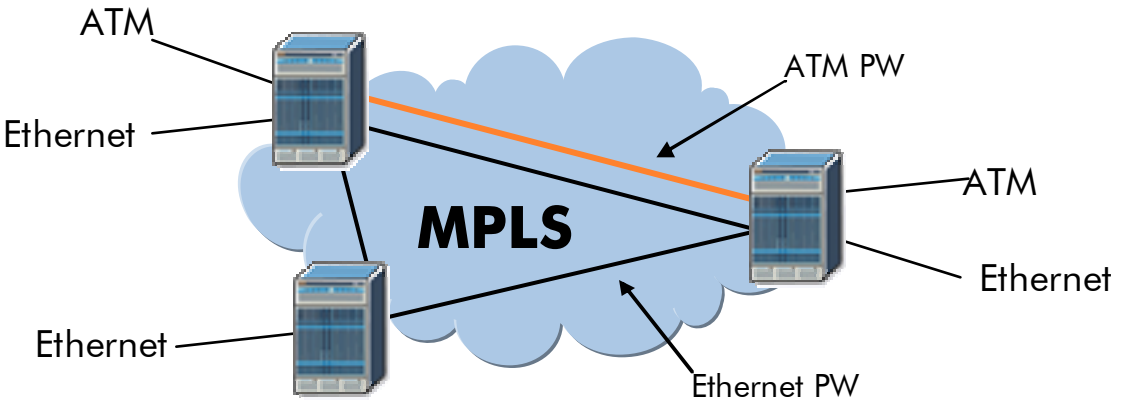
- Service providers are introducing new MPLS based packet switched core networks
  - They are introducing Ethernet in the access
- Motivations:
  - Generate new revenues by broadening the range of services delivered from the IP network
  - Extend the reach of existing Ethernet/FR/ATM services to new sites
  - Interconnect regional ATM networks over a national IP/MPLS network
  - Reduce CAPEX and possibly OPEX
  - **Avoid per-service/per-technology networks**

Standard Service Convergence Solutions

- Based on **Layer 2 Network and Service Interworking** functions
- **Network Interworking:**
  - Allows networks to communicate transparently across different link layer technologies
  - Interworking is performed at the link layer (L2) by encapsulating one link layer in the other
  - Typically deployed inside the network and is not visible to end-users
- **Service Interworking:**
  - Allows CPEs to exchange service layer PDU across different link layer technologies
  - Interworking is performed by terminating the link layers and translating based on knowledge of the payload service context
  - Constraints visible to end-users

Network and Service Interworking Benefits

- **Network Interworking:**
  - OPEX & CAPEX reduction across the combined service portfolio and consolidated infrastructure
  - Growing existing service revenues
- **Service Interworking:**
  - Developing new revenue opportunities from a more flexible service offering e.g. offer an Ethernet access service to customers that already have ATM or FR access to a layer 2 VPN

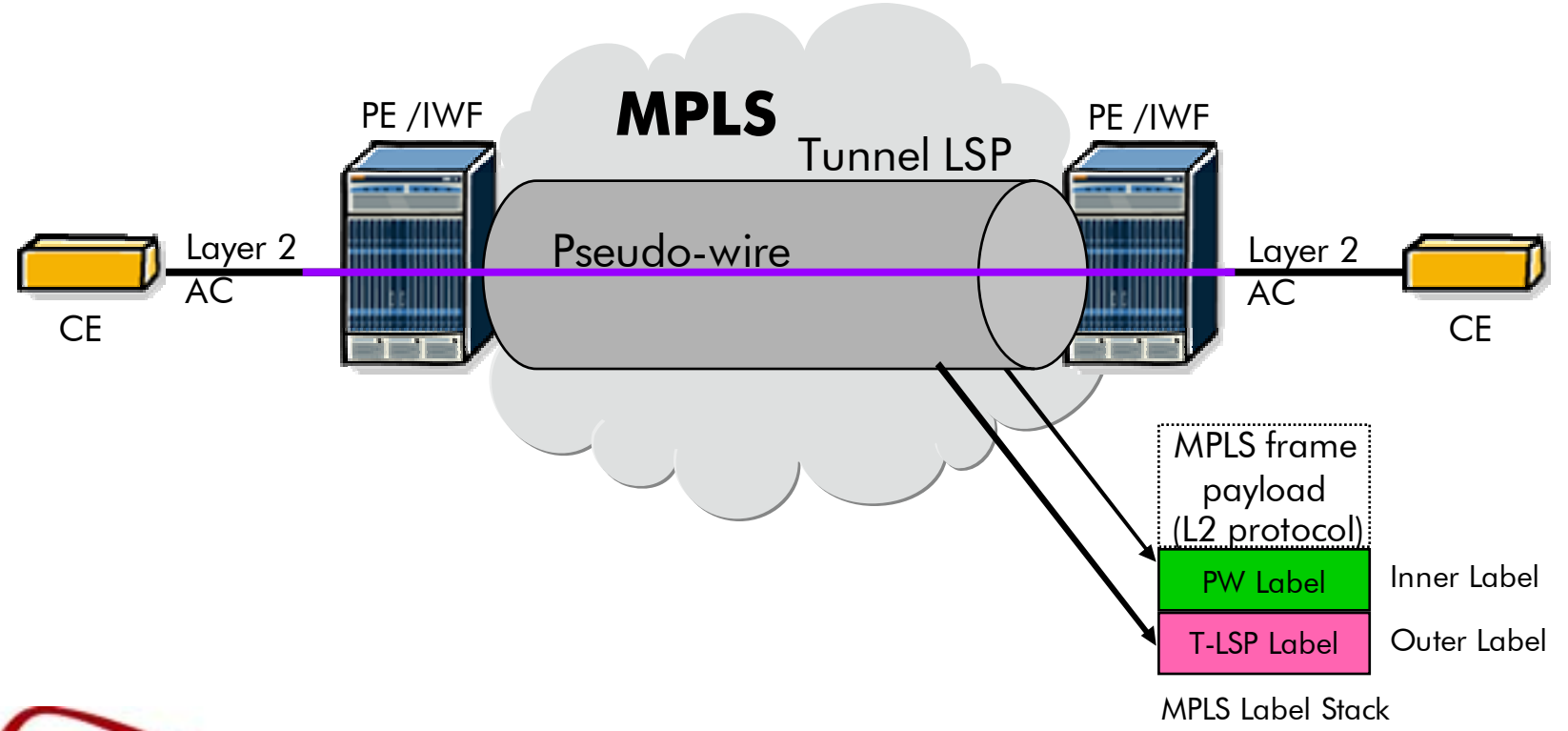


Expectations of the New Converged Packet Network

- Coping with traffic growth in a cost-effective way
  - Enhance utilization of infrastructure
- Carrier class protection and restoration
  - Offer flexible levels of protection (e.g., hot-standby versus warm-standby backup, local versus end-to-end protection)
  - Provide reactive and pro-active OAM capabilities
- Service level differentiation
  - Offer different services with different performance objectives (e.g., VoIP, Virtual Leased Lines, Internet access)
  - Offer multiple grades of the same service (e.g., VoIP gold, silver)
- Intelligent edge policy decision
  - Ability to have visibility and to select specific network resources and apply different policies for routing customer traffic at edge
- Maintaining integrity of L2 services
  - Transparent carriage of existing L2 services
  - Seamless interworking with new services at the user, control , and management (OAM) planes

Basics of Pseudo-Wires

Pseudo Wires are the building blocks of a converged packet network



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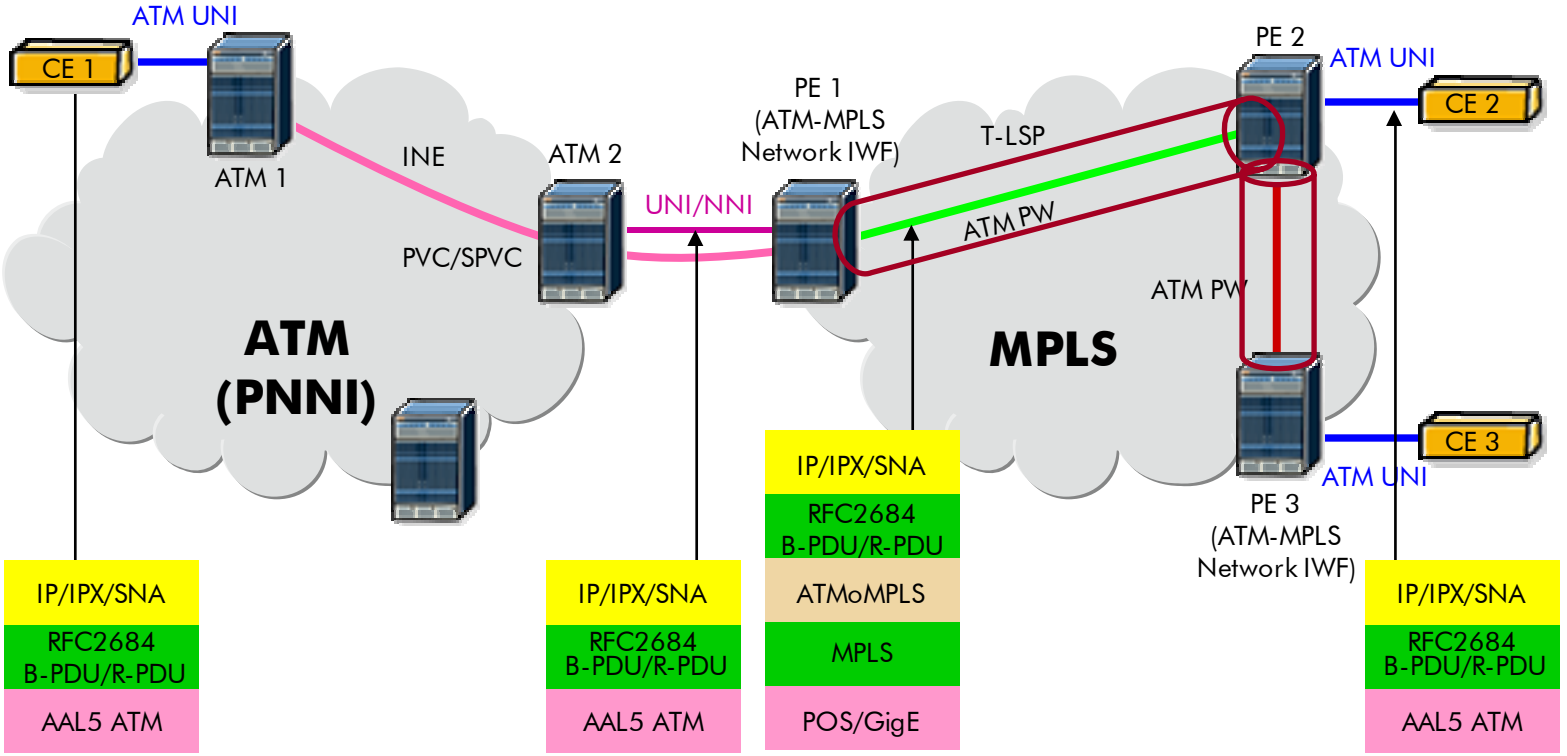
Some L2 VPN Terminology…

- An end-to-end virtual circuit in a L2 VPN consists of a 3 segment set: <AC, PW, AC>
  - AC: attachment Circuit; PW: Pseudo-Wire
- A L2 VPN circuit is homogeneous if AC and PW types are the same
  - E.g., ATM circuit: <ATM AC, ATM PW, ATM AC>
- A L2 VPN circuit is heterogeneous if any two segments of the circuit are of different type
  - E.g., IP interworking circuit: <ATM AC, IP PW, ATM AC>, or <ATM AC, IP PW, FR AC>

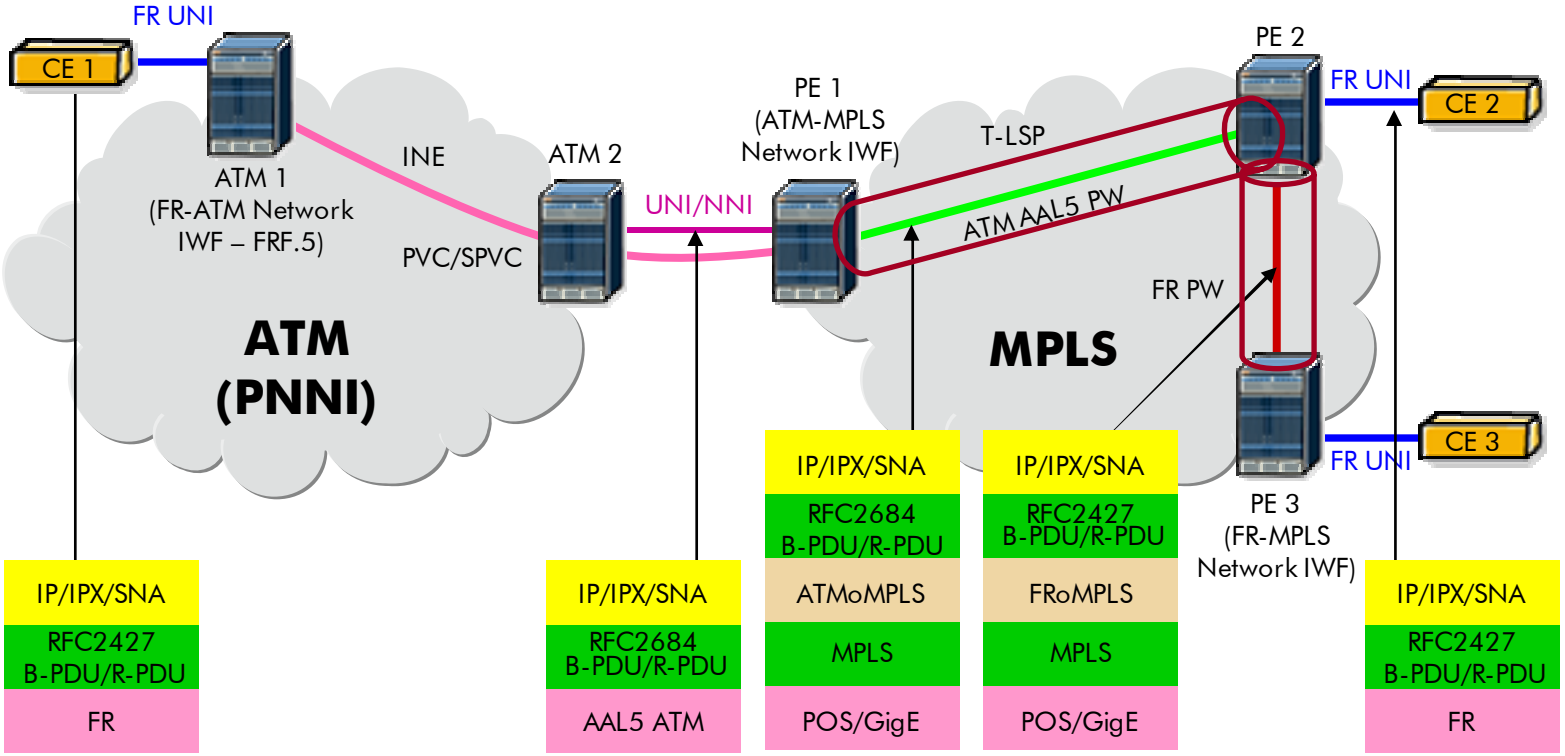
Types of Interworking over MPLS

- Network Interworking
  - ATM/MPLS using <ATM AC, ATM PW, ATM AC> circuits
  - FR/MPLS using <FR AC, FR PW, FR AC> circuits
  - Ethernet/MPLS using <Eth AC, Eth PW, Eth AC> circuits
  - FR-ATM network interworking (FRF.5) using <FR AC, ATM/FR PW, ATM AC> circuits
- Service Interworking
  - FR-ATM service interworking (FRF.8.2) using <FR AC, ATM/FR PW, ATM AC> circuits
  - Ethernet interworking using <Eth/ATM/FR AC, Eth PW, Eth/ATM/FR AC> circuits
  - IP interworking using <Eth/ATM/FR AC, IP PW, Eth/ATM/FR AC> circuits

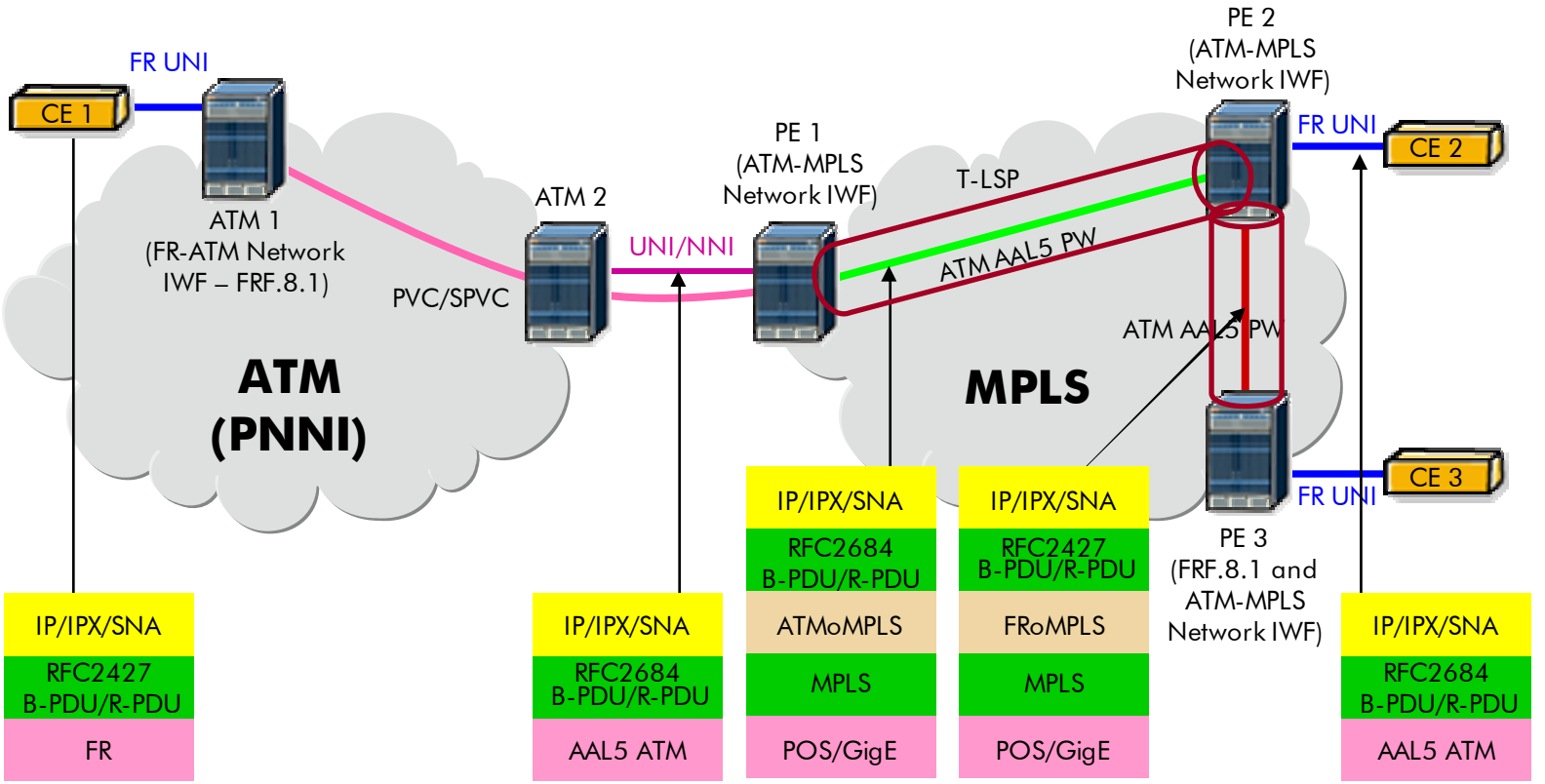
ATM-MPLS Network Interworking



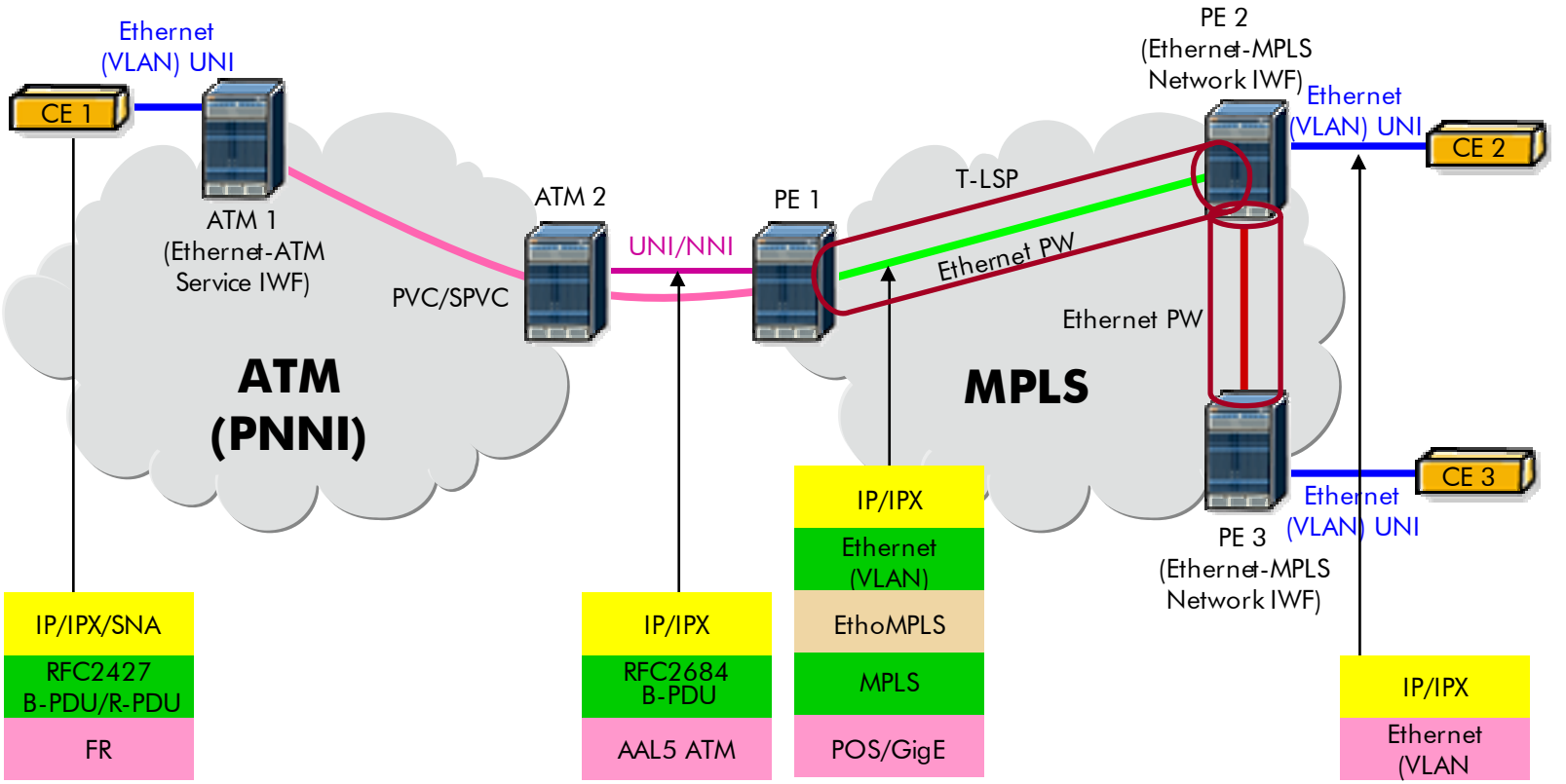
FR-ATM and FR-MPLS Network Interworking over MPLS



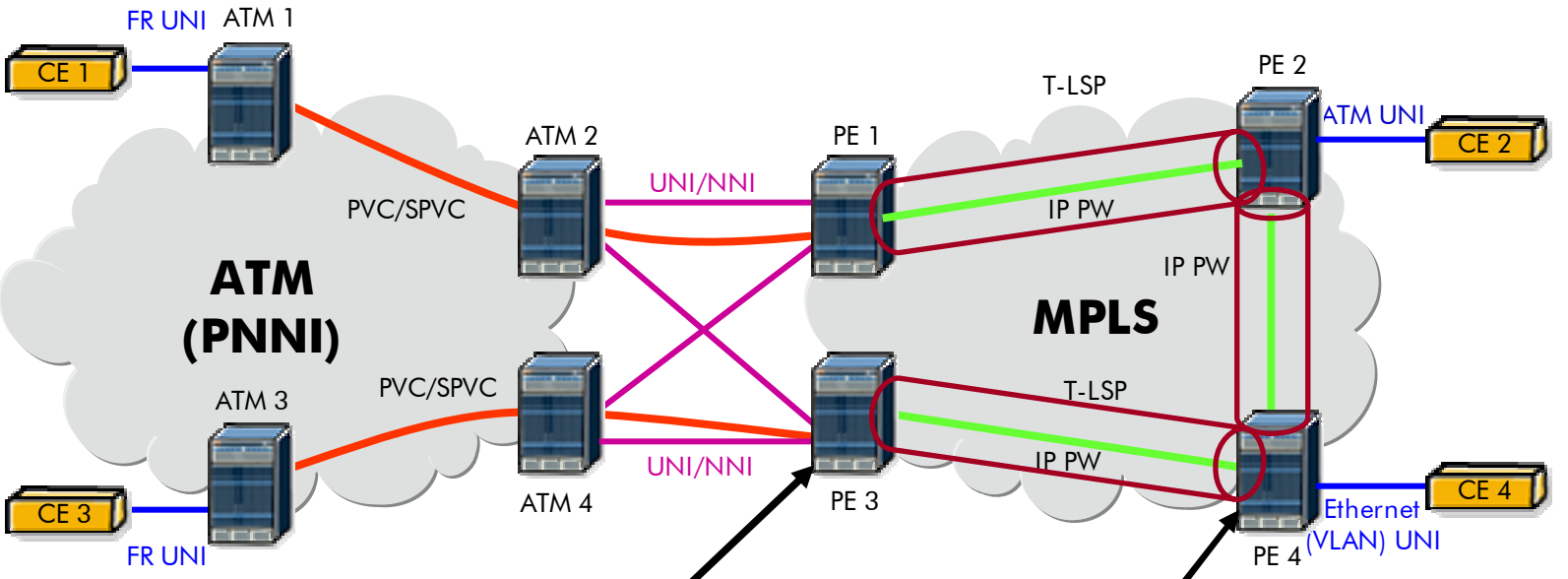
FR-ATM Service Interworking over MPLS



FR-ATM Service Interworking over MPLS



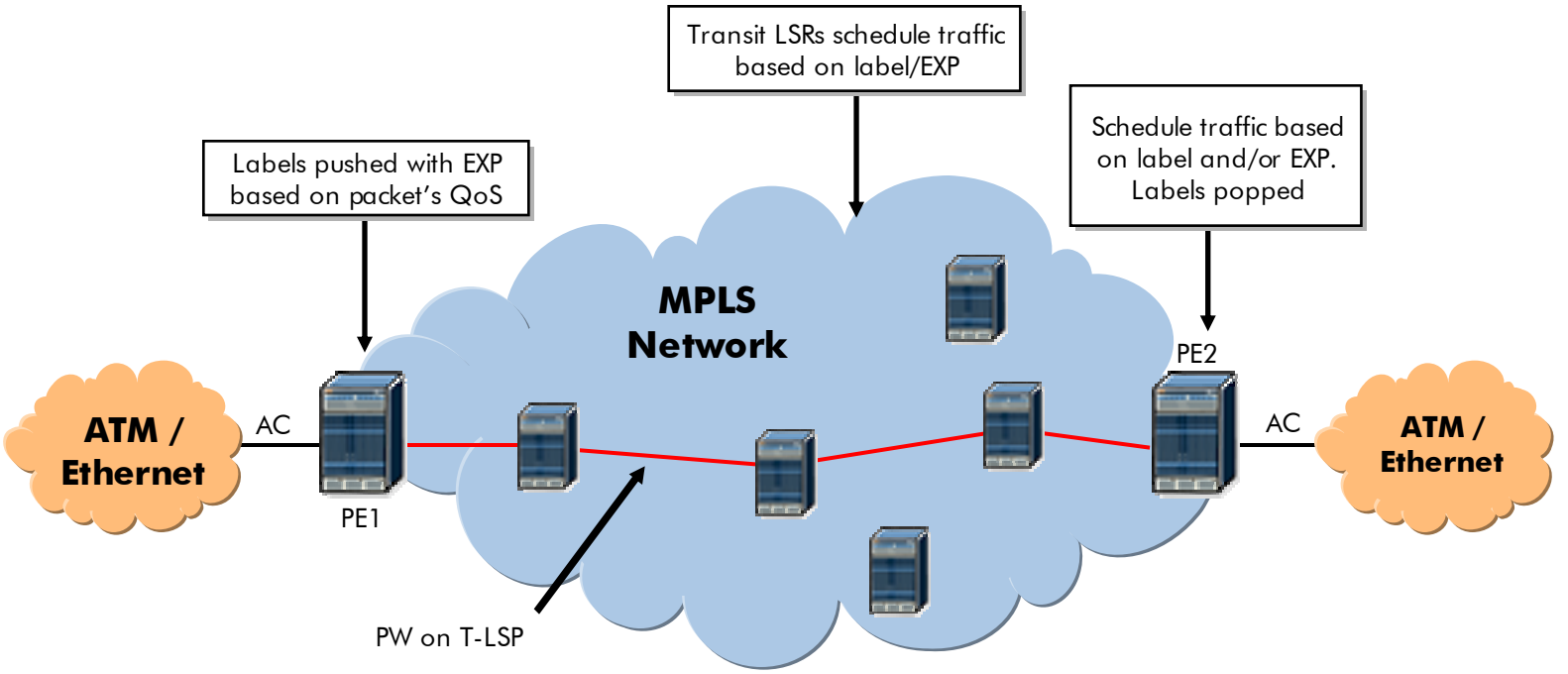
IP Interworking over MPLS



End-to-End QoS

- Ingress Classification
  - MFC, DSCP, 802.1p, L2 I/F context (e.g., ATM Service category & CLP)
  - <CoS, DP> assigned to packet
- Ingress Policing
  - Per L2 CoS policing, e.g., Per VPI/VCI/CLP in a ATM AC
- Queuing and Scheduling in PE
  - Based on assigned <CoS, DP>
- Admission control in PE
  - Tunnel LSP is assigned bandwidth
  - PW are CACed against tunnel bandwidth
- Egress remarking in PE
  - Configurable mapping of <CoS, DP> to EXP
- Queuing and Scheduling in Core LSR
  - According to the label value and EXP value for a L-LSP
  - According to the EXP value for a E-LSP

Example of QoS Support



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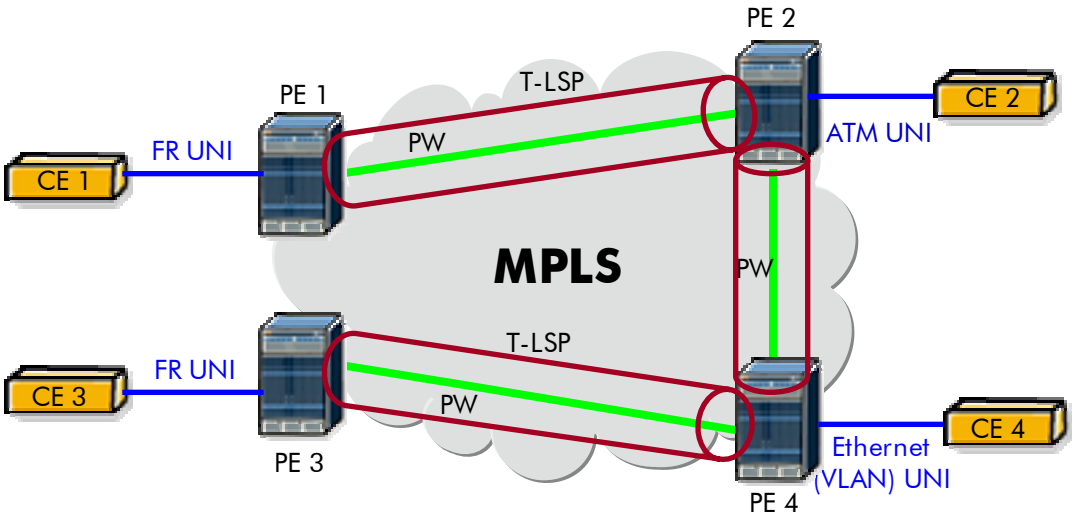
Connectivity Scenarios Across the MPLS Network

- Scenario 1:
  - Connectivity of sites attached to the MPLS network
- Scenarios 2 & 3:
  - Connectivity of sites attached to FR/ATM networks across the MPLS network
- Scenario 4:
  - Connectivity of a site attached to a FR/ATM network to a site attached to the MPLS network

Scenario 1: Targeted LDP Signaling



- Targeted LDP is used for PW setup and maintenance
- Provides PW setup/release and status e.g. down
- draft-ietf-pwe3-control-protocol-08.txt

Scenario 2 & 3: Integrated vs. Distributed Approaches

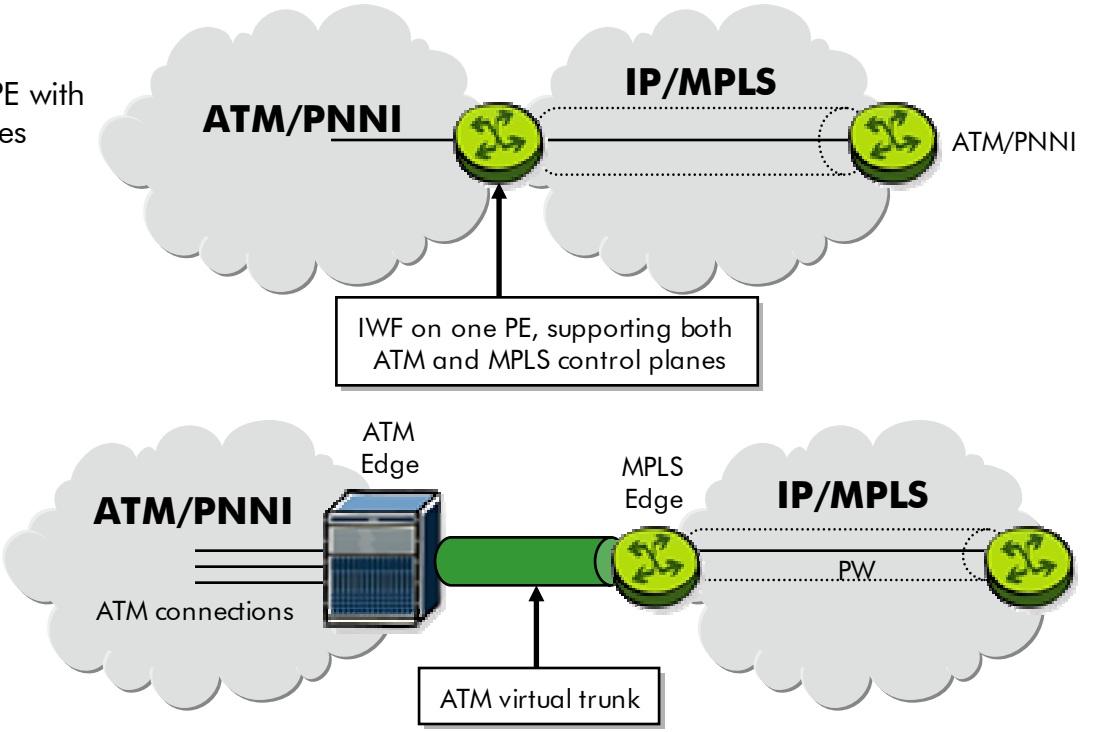
Two approaches to ATM<->MPLS network interconnection

Integrated Model

Interworking function supported on a single PE with both MPLS and ATM (PNNI/AINI) control planes
>Direct ATM control of MPLS tunnel resources
>1:1 mapping from ATM connections to PWs

Distributed Model

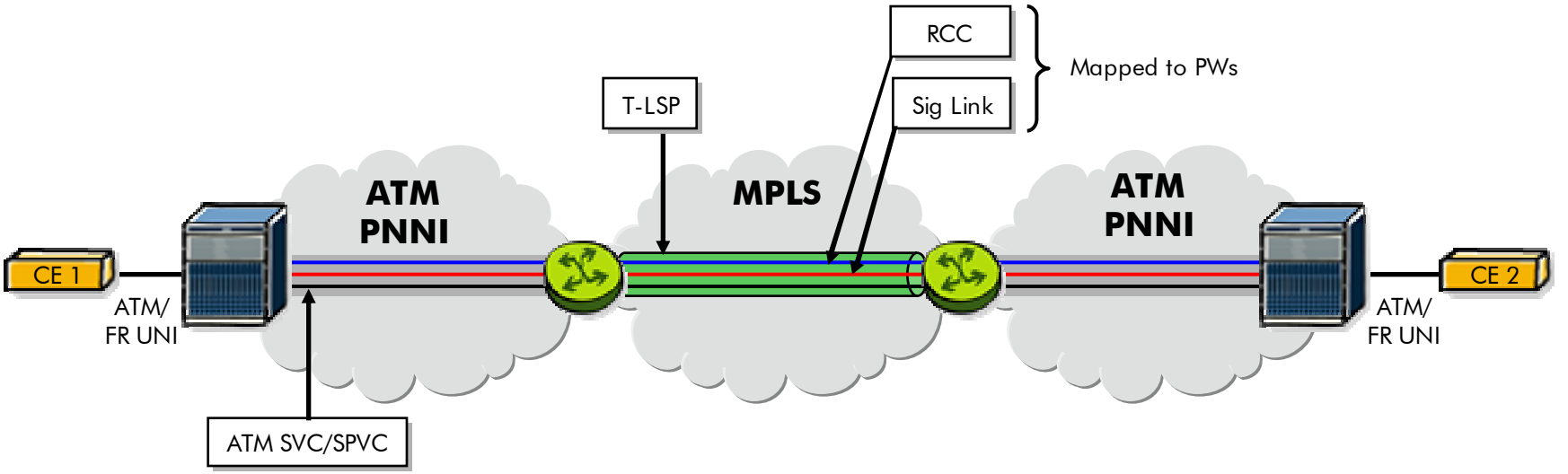
ATM & MPLS control planes supported on different edge devices
>Maintains admin separation between ATM & MPLS networks
>ATM control plane tunnelled over a virtual trunk, mapped to a PW (N:1 mapping)



Extended PNNI

- Designed for transparently interconnecting ATM/PNNI networks using SVCs and SPVCs over MPLS core
- ATM/PNNI and MPLS both run on the PE (Integrated model)
- Extension to PNNI allows it to allocate PW label on PSN tunnel
  - 1:1 mapping between ATM connections and PWs, but can use any PW encapsulation (1:1, N:1, AAL5 SDU, AAL5 PDU)
  - PSN tunnel looks like a virtual PNNI port
- Standardised in ATM Forum: AF-CS-0197
- Interoperability demonstrated at SuperComm 2004

Extended PNNI: Architecture



ATM Signaling for ATM-MPLS Network Interworking:
>ATM Forum AF-CS-0197.000
>draft-bocci-l2vpn-pnni-mpls-iw-00.txt

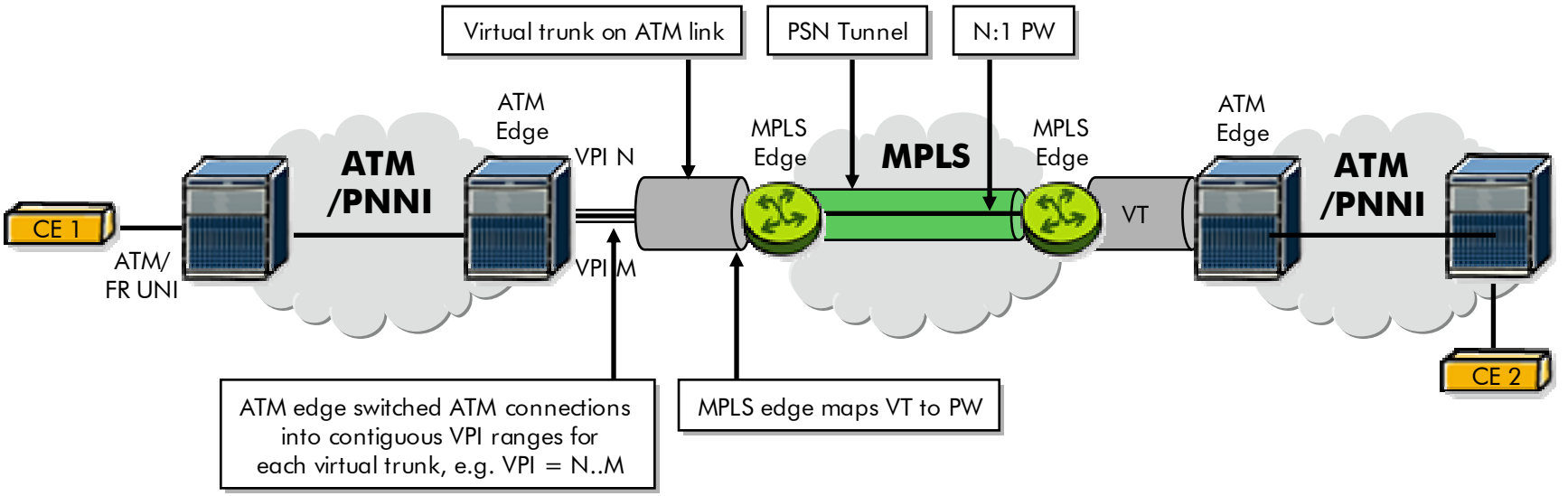
Properties of Extended PNNI

- Independence between IGP and PNNI routing domains
- Requires PNNI and MPLS on the same PE
  - No changes to any other switches or LSRs
- Uses any of the standard ATM PW types, but maps 1 ATM connection to 1 PW
  - Simple QoS support
  - Same OAM model as ATM today
- No impact on MPLS core from high ATM signalling loads
- Full transparency to all ATM switched services and future evolution of PNNI
- PNNI can be used for ATM PW protection / restoration

Virtual Trunking

- Range of ATM connections with the same VPI mapped to a virtual trunk at ATM edge
- Virtual trunk is mapped to a N:1 PW at the MPLS edge
- Targeted at the distributed model
- Virtual trunk is established by provisioning
- Two QoS models under discussion:
  - Implicit QoS: Each VT is a single QoS class, PW is effectively an L-LSP
  - Explicit QoS: Each packet of a given VT can have a different QoS treatment, specified using MPLS EXP bits, PW is effectively an E-LSP
    - Requires communication of QoS setting from ATM switch to PE.

Virtual Trunking: Architecture

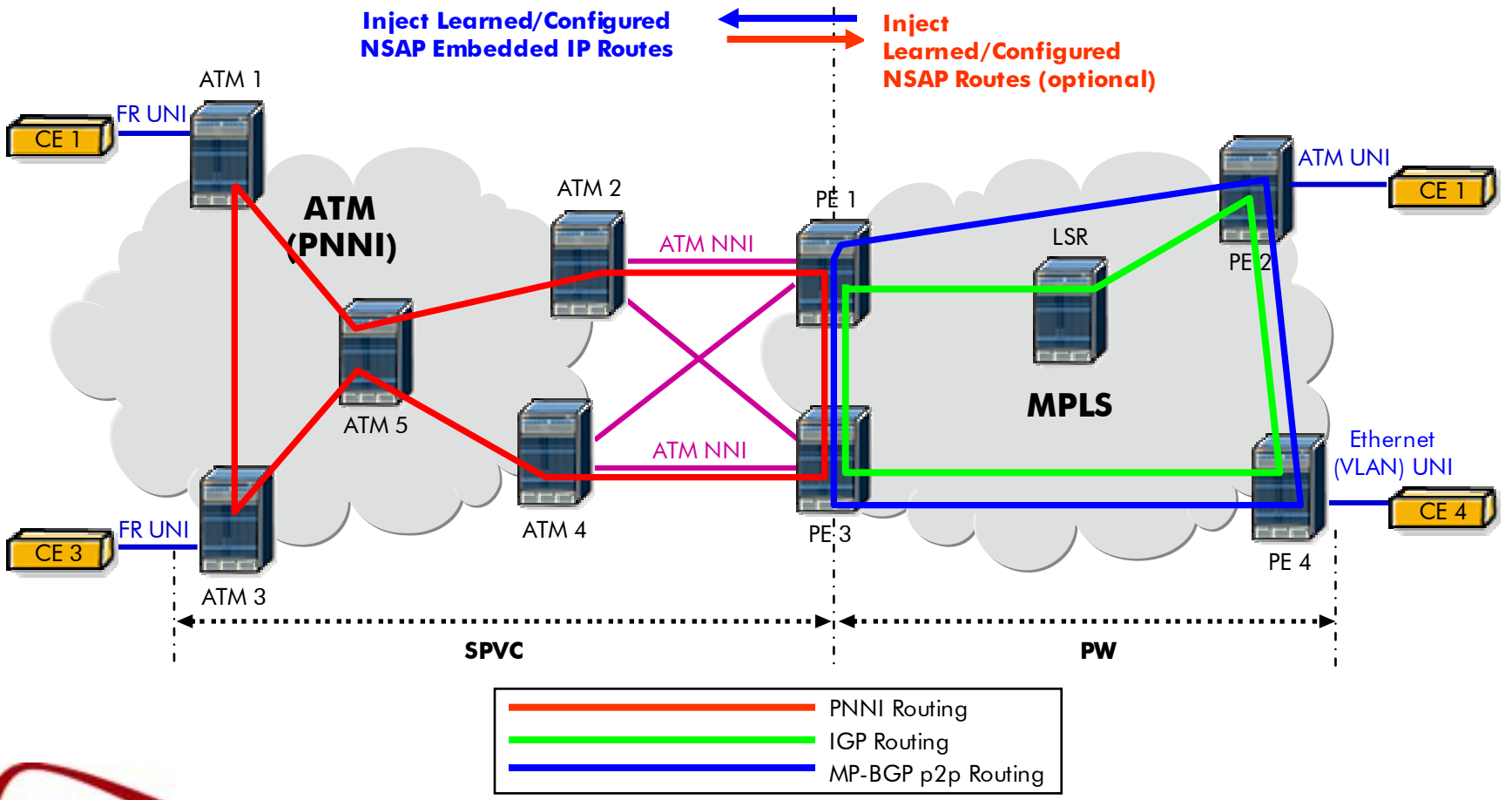


> PNNI RCCs and Sig links tunnelled transparently over VT.
> One VT for each pair of interconnected ATM switches.

Properties of Virtual Trunking

- Independence between IGP and PNNI routing domains
- Allows separation of PNNI and MPLS between ATM edge and MPLS edge
- Uses only N:1 ATM PW, maps many ATM connections to each PW
  - Must be provisioned a-priori
  - OAM treatment of a VT needs to be defined
- No impact on MPLS core from high ATM signalling loads
- Full transparency to all ATM switched services and future evolution of PNNI
- PNNI can be used for ATM PW protection / restoration
- Not yet standardised: Under development in MPLS/FR Alliance

Scenario 4: SPVC-PW Interworking



Overview of SPVC-PW Interworking

- Routing
  - LER reachability is configured in the ATM-MPLS GW (PE1/PE3)
    - LERs are assigned IP embedded NSAP addresses
  - PE1 advertises configured IP embedded NSAP routes into PNNI peer-group as externally reachable prefixes
  - SPVC launched from PNNI endpoint
    - ATM/MPLS GW (PE1/PE3) does not advertise PNNI routes to LERs
    - Routing interworking of PNNI and MP-BGP not required initially
- Signaling
  - End-to-end SPVC consists of a bi-directional PNNI source routed SPVC and a bi-directional PW
  - Requires synchronization of call handling procedures between bidirectional PNNI/AINI/UNI signaling and unidirectional LDP signaling
  - Limited translation of signaling messages between PNNI/AINI/UNI and LDP

Described in: draft-swallow-pwe3-spvc-iw-01.txt
draft-watkinson-l2vpn-pnni-psn-framework-01.txt

Properties of SPVC-PW Interworking

- Independence between IGP and PNNI routing domains
- Allows separation of PNNI and MPLS between ATM edge and MPLS edge
- Only applicable to ATM/FR S-PVCs S-PVPs
- Impact on MPLS core from high ATM signalling loads during S-PVC reroute
- S-PVCs can only originate in the ATM network and cannot extend beyond remote PE
- PNNI and MPLS can be used for ATM PW and PE protection / restoration
- Under development in IETF & MPLS/FR alliance

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Convergence on IP/MPLS and Implications on OAM

Reluctance to converge premium services over IP/MPLS without OAM as robust as today's data networks. Critical to OPEX reduction.

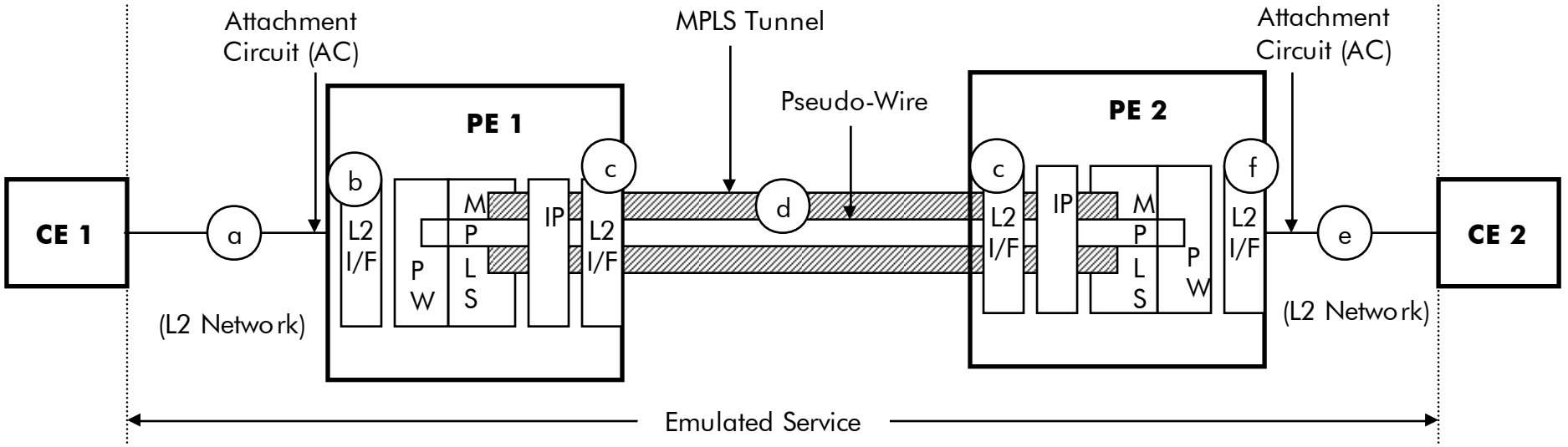
- Provide and coordinate OAM at the relevant levels in the IP/MPLS network
- Proactive and reactive OAM mechanisms which are independent at all levels

Service Level
e.g VRF-Ping, MAC-Ping

VC / PW Level
e.g VCCV, PW status

Transport LSP Level
e.g MPLS OAM

Defect Locations



(a) (e) Defect in the L2 network

(b) (f) Defect on a PE AC interface

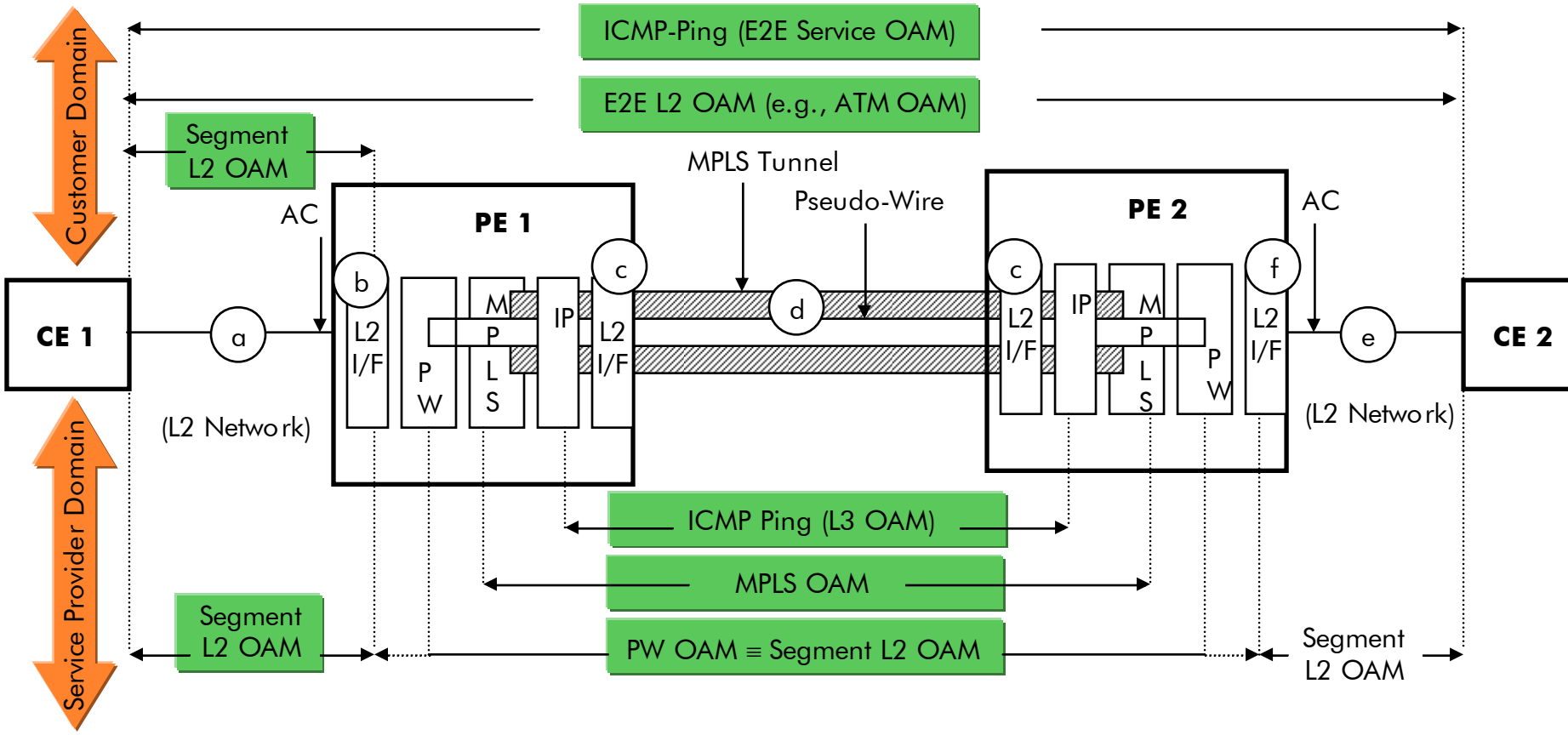
(c) Defect on a PE MPLS interface

(d) Defect in the MPLS network

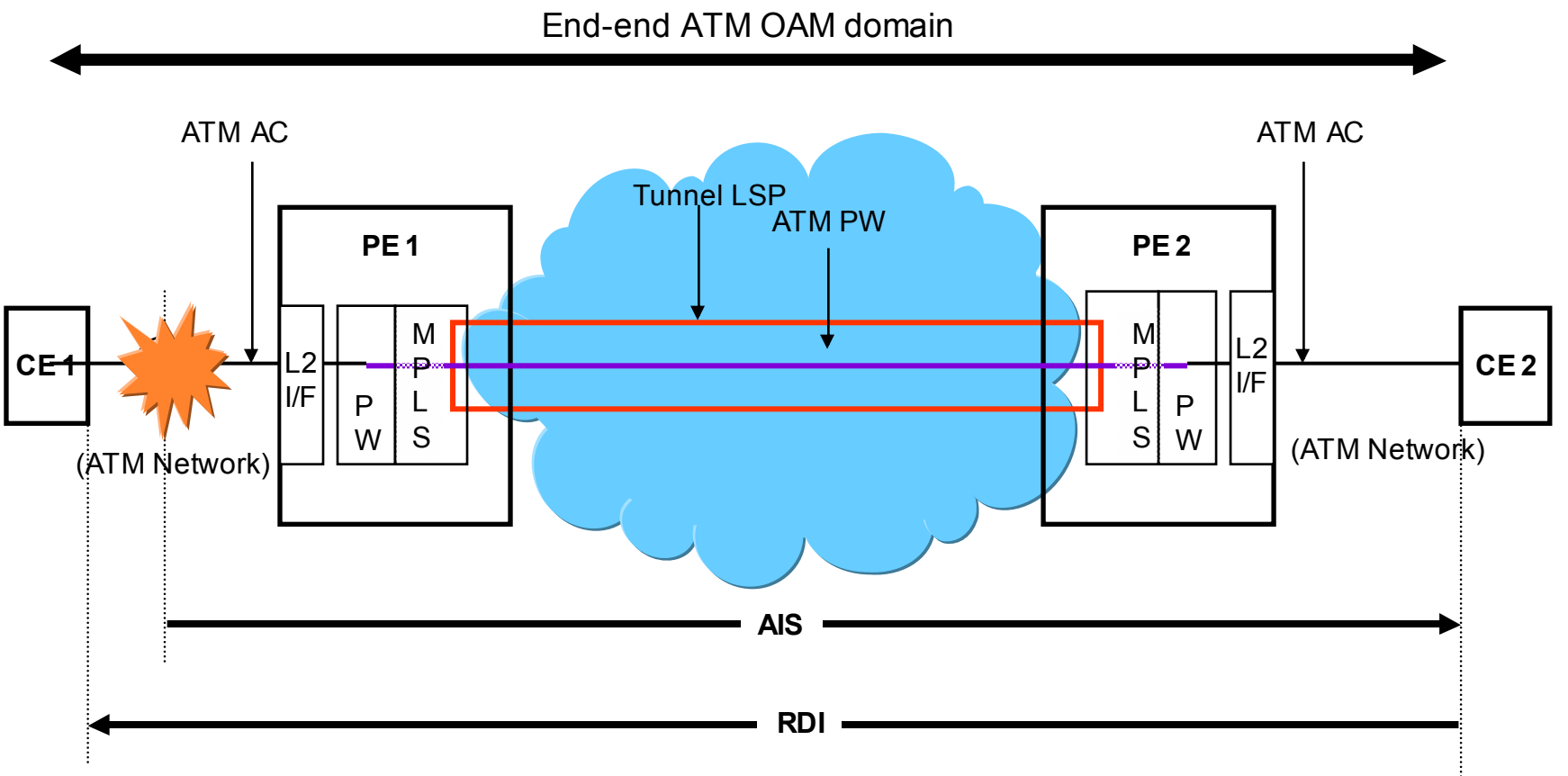
OAM Interworking Models

- Homogeneous L2 VPN Circuit
  - AC link layer not terminated at PE
  - Native service OAM must run inband transparently over MPLS tunnel:
    - it is used for both AC and PW defect indication
  - Exceptions: FR and Ethernet network interworking for a lack of inband OAM
- Heterogeneous L2 VPN Circuit
  - AC link layer terminated at PE
  - Native service OAM always terminates at the AC endpoint in a PE
    - requires PW specific defect indication
    - Out-of-band PW status signaling is used by default
  - Exception: FR-ATM service interworking when PW uses ATM cell mode
- Need to be pragmatic:
  - PW status signaling is default when there is no in-band OAM on PW

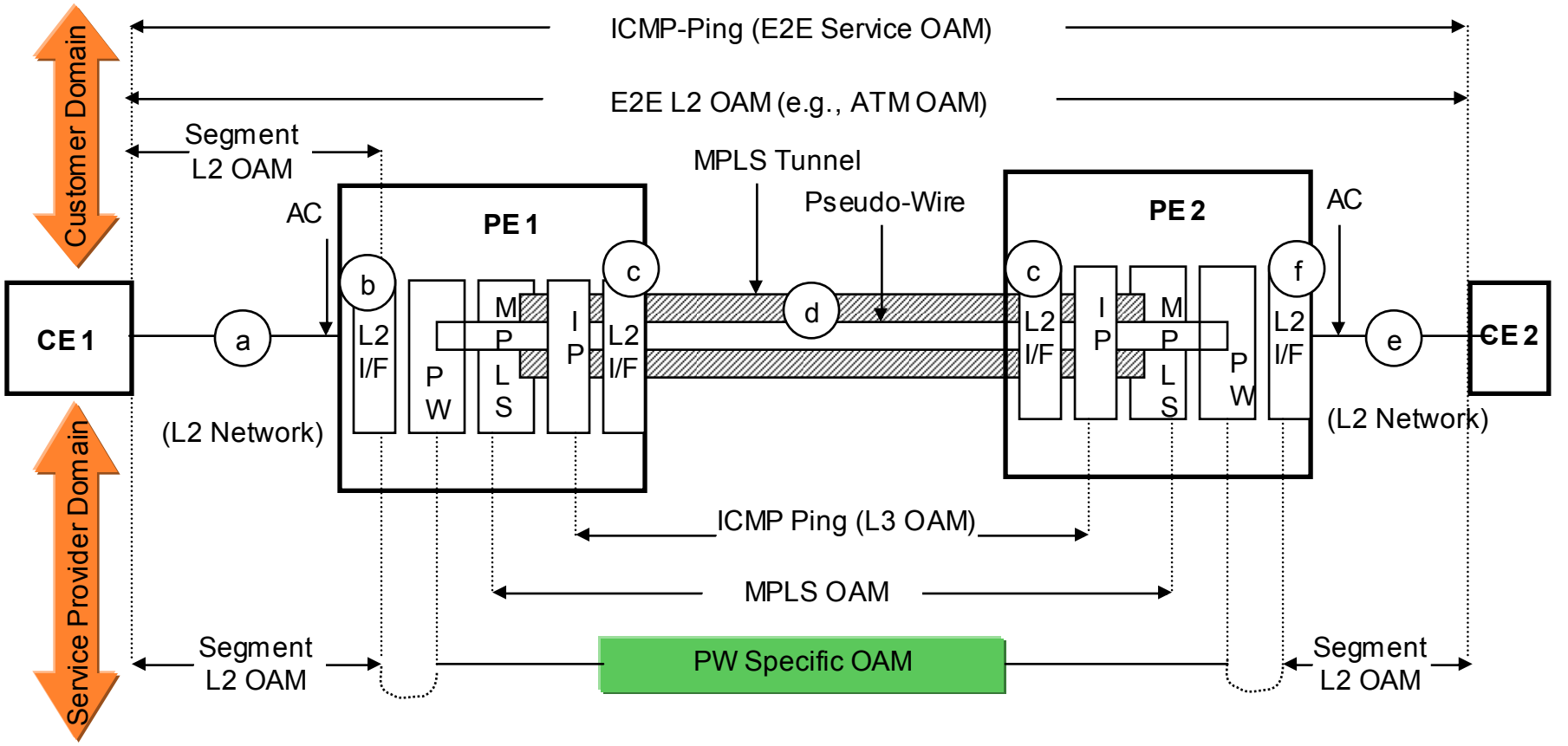
Homogeneous Circuit OAM Model



Homogeneous Circuit OAM Example



Heterogeneous Circuit OAM Model



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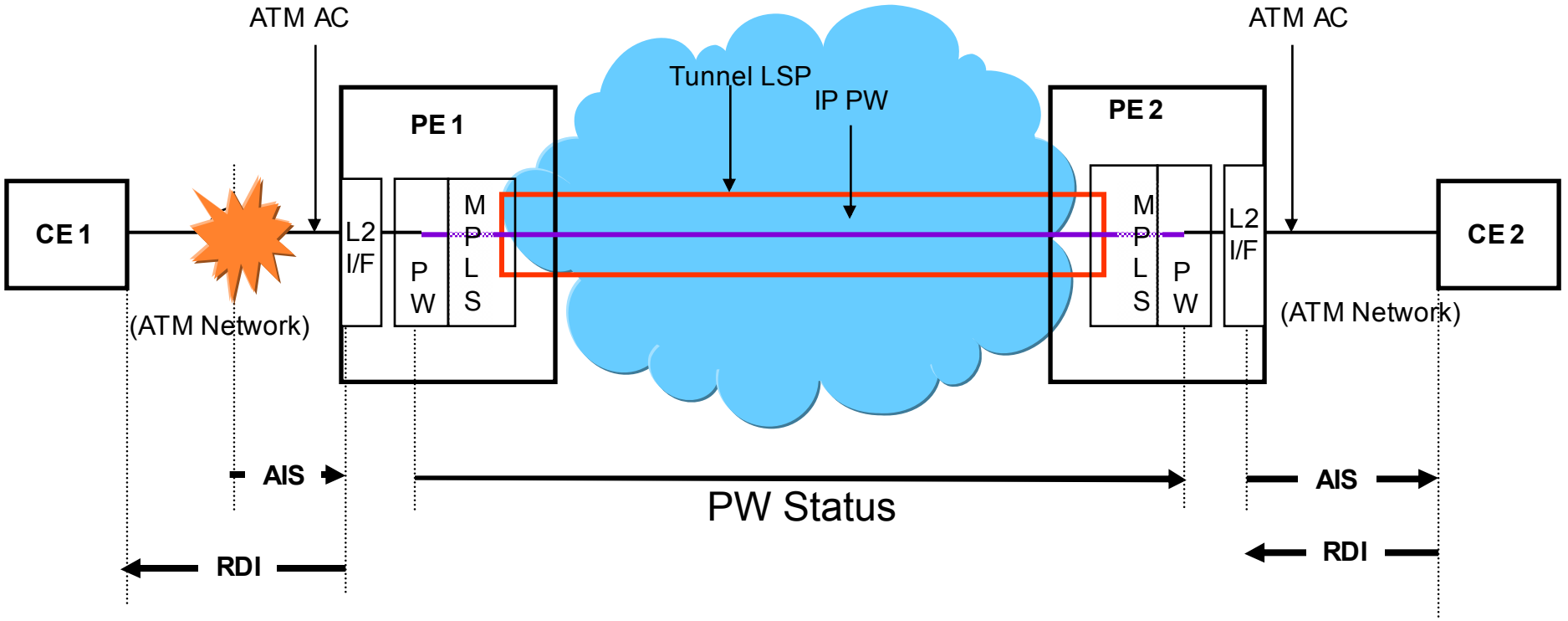

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Conclusions

- **Many carriers are looking at MPLS for Service Convergence**
  - Offering or extending the reach of revenue generating Layer 2 services over an MPLS backbone
  - Converging layer 2 services to leverage the same backbone to provide enhanced revenue generating Layer 3 services

- **Two approaches to support layer 2 services over MPLS**
  - Layer 2 Network Interworking & Service Interworking
  - Will require comprehensive interworking at user, control and management planes to realise potential benefits

References*

- Network and Service User Plane Interworking
  - ATM PW: draft-ietf-pwe3-atm-encap-06.txt
  - Frame Relay PW: draft-ietf-pwe3-frame-relay-03.txt
  - Ethernet PW: draft-ietf-pwe3-ethernet-encap-07.txt
  - IP interworking PW: draft-shah-l2vpn-arp-mediation-01.txt, draft-balus-pwe3-ip-pseudowire-01.txt
  - ATM-MPLS network interworking: ATM Forum af-aic-0178.001
  - ATM-MPLS network interworking: ITU-T Y.1411, Y.1412
  - FR-ATM network interworking: Frame Relay Forum FRF.5
  - FR-ATM service interworking: Frame Relay Forum FRF.8.2
  - FRF.8.2 over MPLS: MPLS FR Alliance work in progress
  - Ethernet interworking over MPLS: MPLS FR Alliance work in progress
- Control Plane Interworking
  - PW signaling: draft-ietf-pwe3-control-protocol-08.txt
  - ATM Signaling for ATM-MPLS Network Interworking (Extended PNNI):
    - ATM Forum AF-CS-0197.000
    - draft-bocci-l2vpn-pnni-mpls-iw-01.txt
  - ATM-PWE3 signaling interworking:
    - draft-swallow-pwe3-spvc-iw-01.txt
    - draft-watkinson-l2vpn-pnni-psn-framework-01.txt

References* (II)

- ATM OAM
  - ITU-T I.610 Recommendation
- FR OAM
  - PVC Management (LMI): ITU-T Q.933 Annex A
  - OAM: Frame Relay Forum FRF.19
- MPLS OAM
  - LSP-Ping and Trace-Route: draft-ietf-mpls-lsp-ping-04.txt
  - MPLS OAM requirements: draft-ietf-mpls-oam-requirements-02.txt
  - MPLS OAM framework: draft-allan-mpls-oam-frmwk-05.txt
  - MPLS OAM: ITU-T Y.1711
- L2 VPN and Pseudo-Wire (PW) OAM
  - draft-ietf-l2vpn-vpls-ldp-04.txt
  - draft-aissaoui-l2vpn-vpws-iw-oam-01.txt
  - draft-ietf-pwe3-vccv-01.txt
  - draft-ietf-pwe3-oam-msg-map-00.txt
  - draft-ietf-pwe3-atm-encap-04.txt
  - ITU-T Y.1413

Thank You

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