MPLS-TP in Multi-Service Packet Network Deployments Tutorial

MR-245

October 2010

Agenda

1. Introduction to the Broadband Forum
2. Technology, Market and Business drivers
3. MPLS-TP Technology Overview – Architecture, data plane, OAM, control plane, survivability
4. MPLS(-TP) Use Cases
5. Broadband Forum Applicability
6. Network Scenarios
7. Summary

We are the Broadband Forum

http://www.broadband-forum.org

- The Broadband Forum is the central organization driving broadband solutions and empowering converged packet networks worldwide to better meet the needs of vendors, service providers and their customers.

- We develop multi-service broadband packet networking specifications addressing interoperability, architecture and management. Our work enables home, business and converged broadband services, encompassing customer, access and backbone networks.

- Disclaimer: this tutorial is provided solely for educational purposes. At this point, the applicability of MPLS-TP to BBF architectures and solutions is under active study. Options shown are examples of potential uses. Implementations and architectural requirements are specified in BBF Technical Reports.

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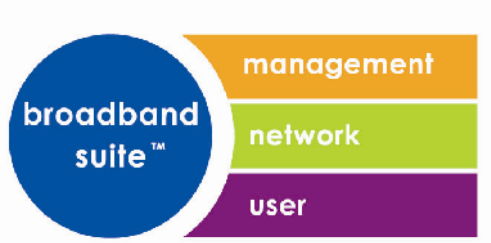
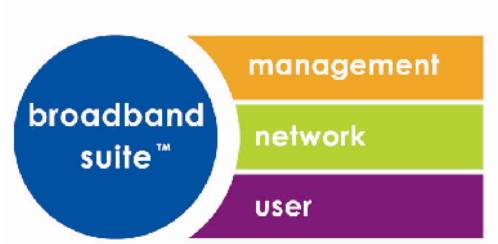
The BroadbandSuite
Goals and Focus

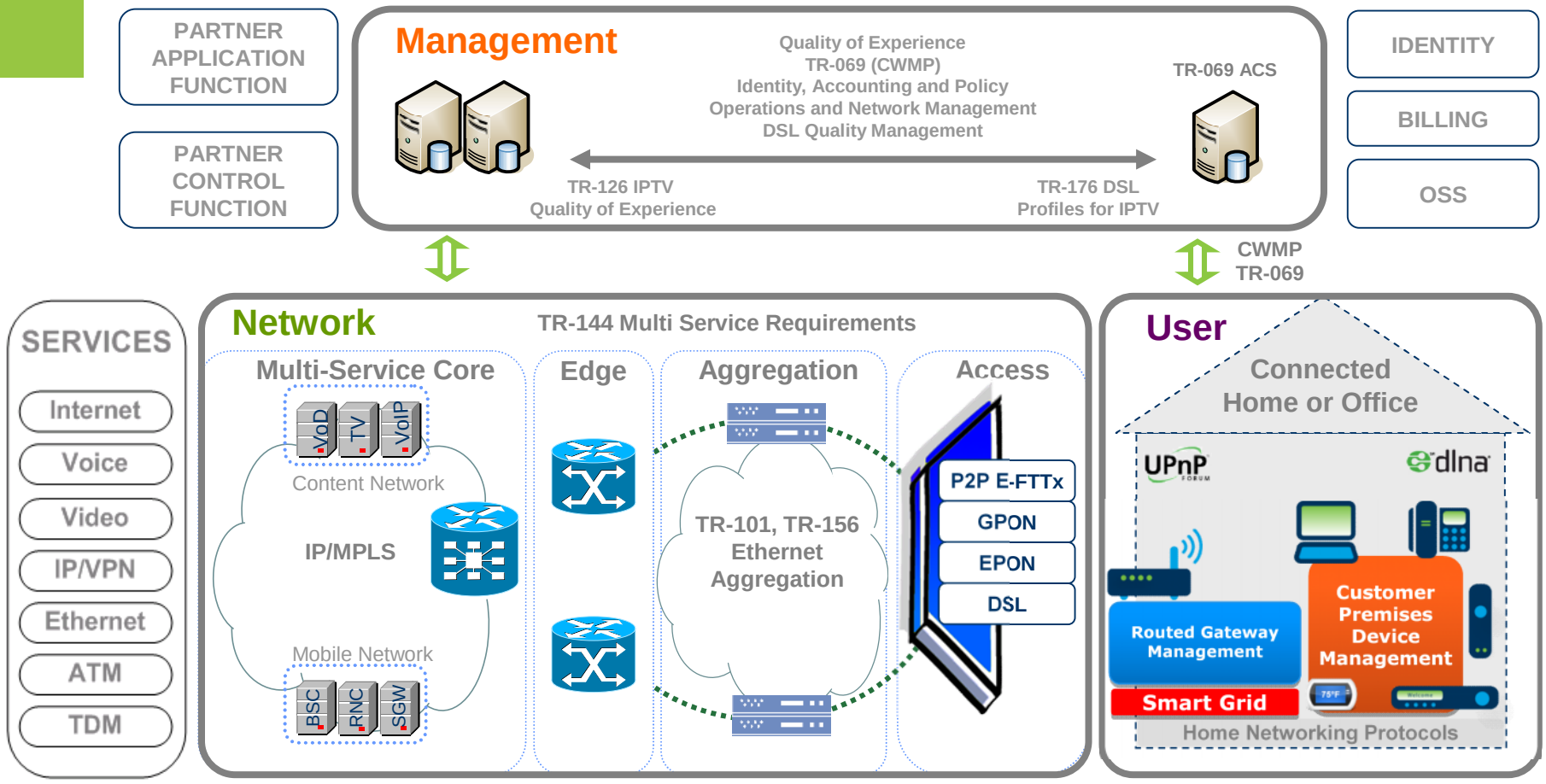


The BroadbandSuite is broken down into three major domains:

- **BroadbandManagement**
  - **Goal –** enhance network management capabilities and enable an intelligent, programmable control layer that unifies diverse networks
  - **Focus** - empower service providers to deliver and efficiently maintain personalized services that enhance the subscriber experience
- **BroadbandNetwork**
  - **Goal** - establish network architecture specifications to support current and emerging services and applications
  - **Focus** - deliver access, aggregation and core specifications that provide inherent interoperability, quality, scalability and resiliency capabilities from end-to-end
- **BroadbandUser**
  - **Goal** - Define unified networking standards by establishing a common set of CPE capabilities within the business, home and mobile environments
  - **Focus** - Simplify the service delivery process by developing common devices' identification, activation, configuration and maintenance specifications

Broadband Forum Scope





Multi Service Architecture & Requirements **Certification, Test and Interoperability**

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The Broadband Forum Documents

The Broadband Forum uses the following nomenclature for its Documents –

- **Technical documents**
  - Technical Reports (TRs, TR-nnn)
  - Working Texts (WTs, WT-nnn)
  - Proposed Drafts (PDs, PD-nnn)
- **Marketing documents** (white papers and tutorials)
  - Marketing Reports (MRs, MR-nnn)
  - Marketing Drafts (MDs, MD-nnn)

TRs and MRs are available via the BBF website http://broadband-forum.org/.

WTs, PDs and MDs are works in progress and generally available to members only.

Technology, Market and Business drivers

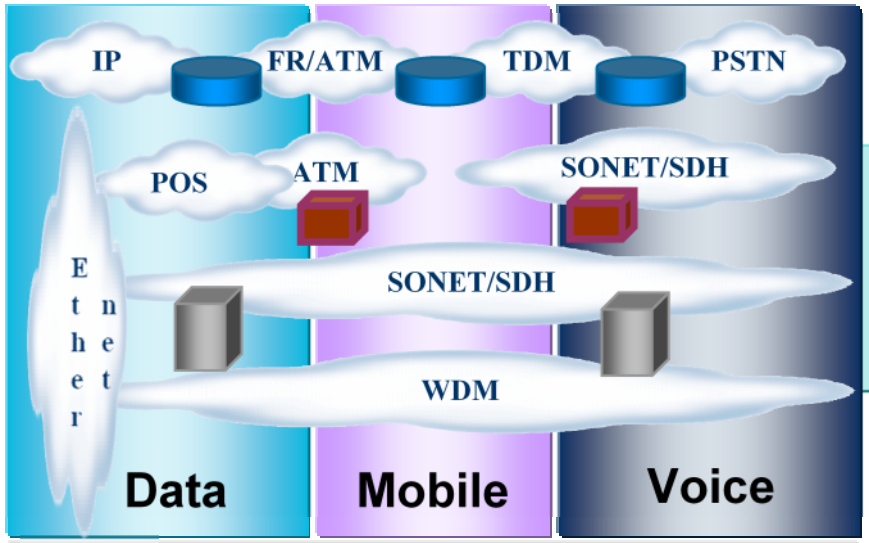
Why MPLS in transport?
Requirements on MPLS

Market drivers for Packet Transport Evolution

- Fast growing bandwidth demand - driven by new packet applications/services
  - IP Video: content downloading/streaming/sharing
  - Mobile data: e.g. smart phone applications
  - Triple play
  - IP and Ethernet VPNs
- Network convergence and Technology refresh
  - Consolidate networks onto common infrastructures
  - Replace aging legacy networks
  - Flexibility to adapt to different types of traffic and topologies
- Cost saving advantages
  - Flexible data rates
  - Statistical Multiplexing gains, where needed
  - Lower operational costs

IP and Ethernet Services Drive Network Transformation

Multiple Legacy Networks



Multiple layers, separate single function networks

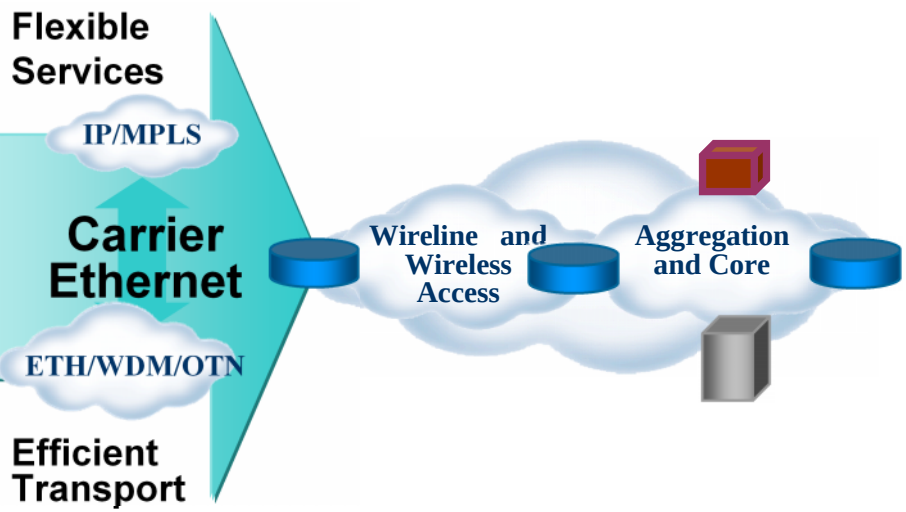
"Verticalized", stovepiped infrastructure

Complicates service and network transformation

Multiple single services

Circuit-based transport

Converged Infrastructure



Fewer layers, converged multi-function network

"Horizontalized", more homogenized infrastructure

Enables service and network transformation

Multi-service, application aware

Converged packet-enabled transport

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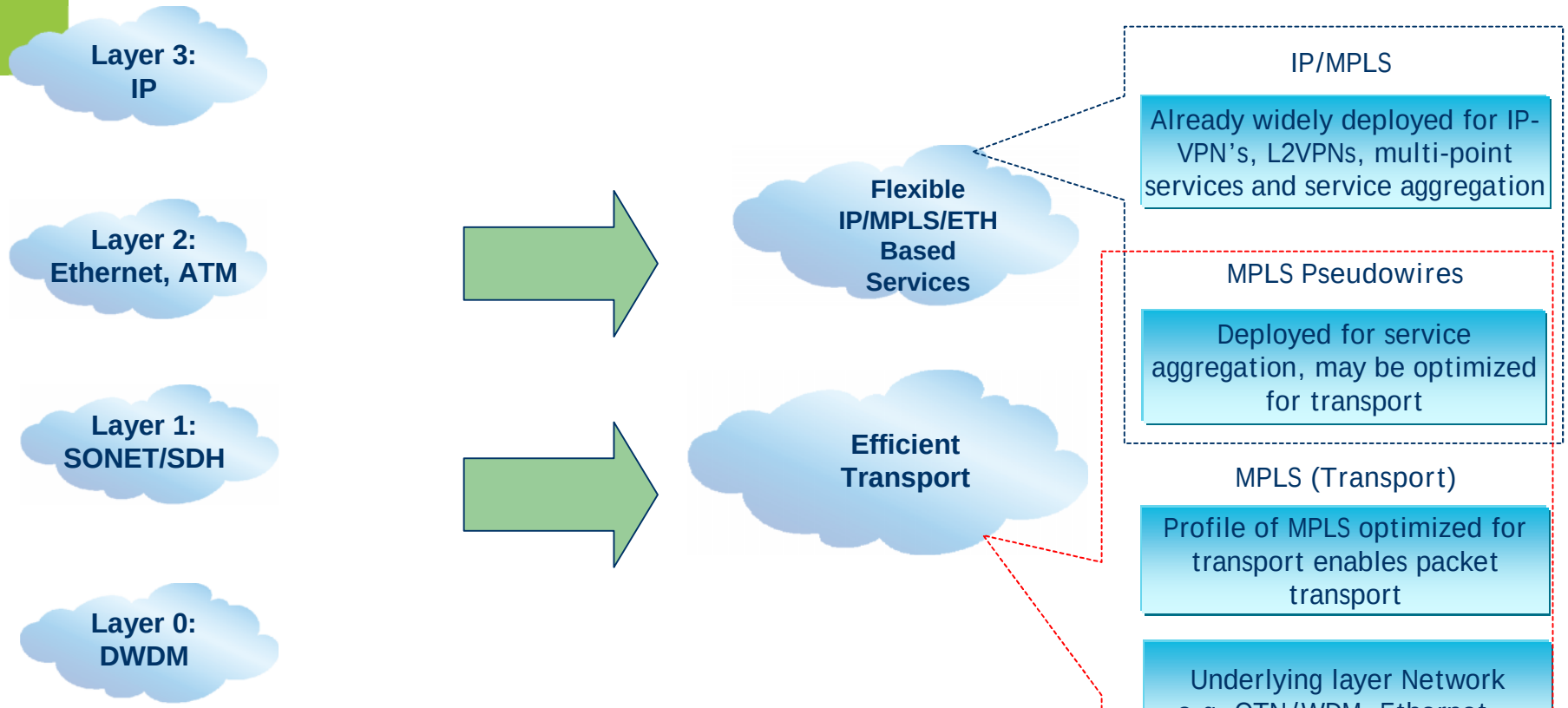
Simplifying Data Services and Packet Transport



IP-MPLS-Ethernet services over converged packet transport

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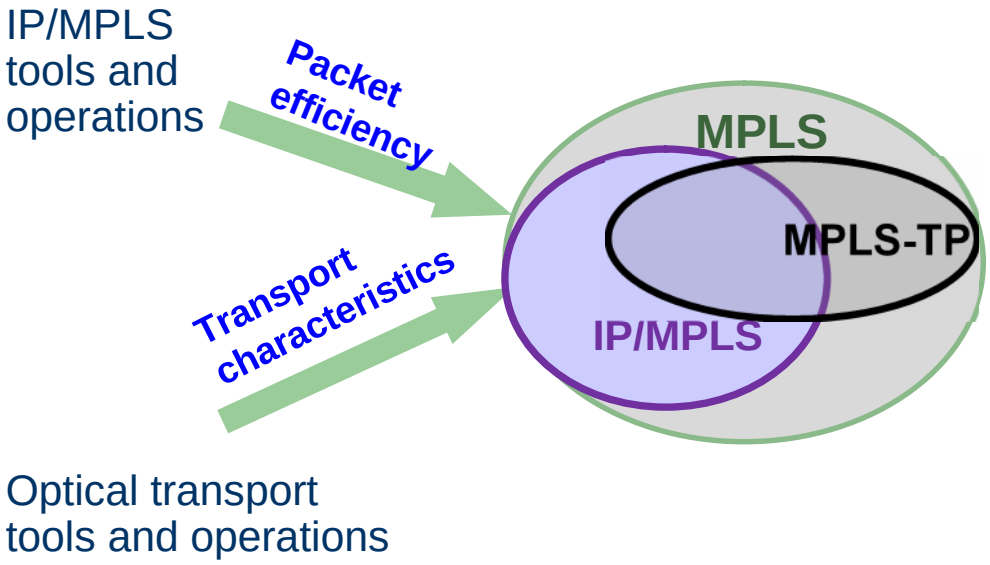
Case for MPLS in Packet Transport



MPLS:

- Is Multiservice
- Is carrier-grade
- Offers connection-oriented operation with Traffic Engineering capability
- Is widely deployed in service routing and core
- Enables true convergence between transport and packet networks
  - Capex and Opex savings
- Can be easily profiled for packet transport

MPLS-TP bridges the gap between the transport and packet worlds allowing true convergence

See RFC5921: A Framework for MPLS in Transport Networks

Requirements on MPLS Transport Profile

Transport-Centric Operational Model
NMS Configuration without Control Plane, or fully Dynamic Control Plane
Data plane capabilities independent of Control plane

Protection Switching
Triggered by OAM (i.e., not dependent on dynamic signalling or Control Plane liveliness)
Efficient operation for both dense mesh and ring topologies

Transport-Optimized OAM
Functions such as Continuity Check/Verification, Performance Monitoring, Alarm Suppression
Not dependent on IP forwarding

Connection-Oriented
Bidirectional Label Switched Paths (LSPs) are co-routed
No LSP merging; no Equal Cost Multipath (ECMP)

Standard MPLS Data-Path
Must operate using standard labels, standard push/pop/swap operations

(Paraphrased from RFC5654)

IETF/ITU-T Joint Working Team (1) Consensus on MPLS-TP

IETF and ITU-T agreed to work together and bring transport requirements into the IETF and extend IETF MPLS forwarding, OAM, survivability, network management, and control plane protocols to meet those requirements through the IETF Standards Process.[RFC5317][1]

Definition of MPLS "Transport Profile" (MPLS-TP) protocols, based on ITU-T requirements

Derive packet transport requirements

Integration of IETF MPLS-TP definition into transport network recommendations

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BBF defines how to apply technologies in broadband networks to allow interoperability and multi-services support.

1: [RFC 5317]: Joint Working Team (JWT) Report on MPLS Architectural Considerations for a Transport Profile, Feb. 2009.

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MPLS-TP Technology Overview

Architecture, Data plane,
OAM, Control plane,
Survivability

MPLS-TP Objectives
(from RFC5654 and RFC5921)

- To enable MPLS to be deployed in a transport network and operated in a similar manner to existing transport technologies (SDH/SONET/OTN).

- To enable MPLS to support packet transport services with a similar degree of predictability, reliability and OAM to that found in existing transport networks

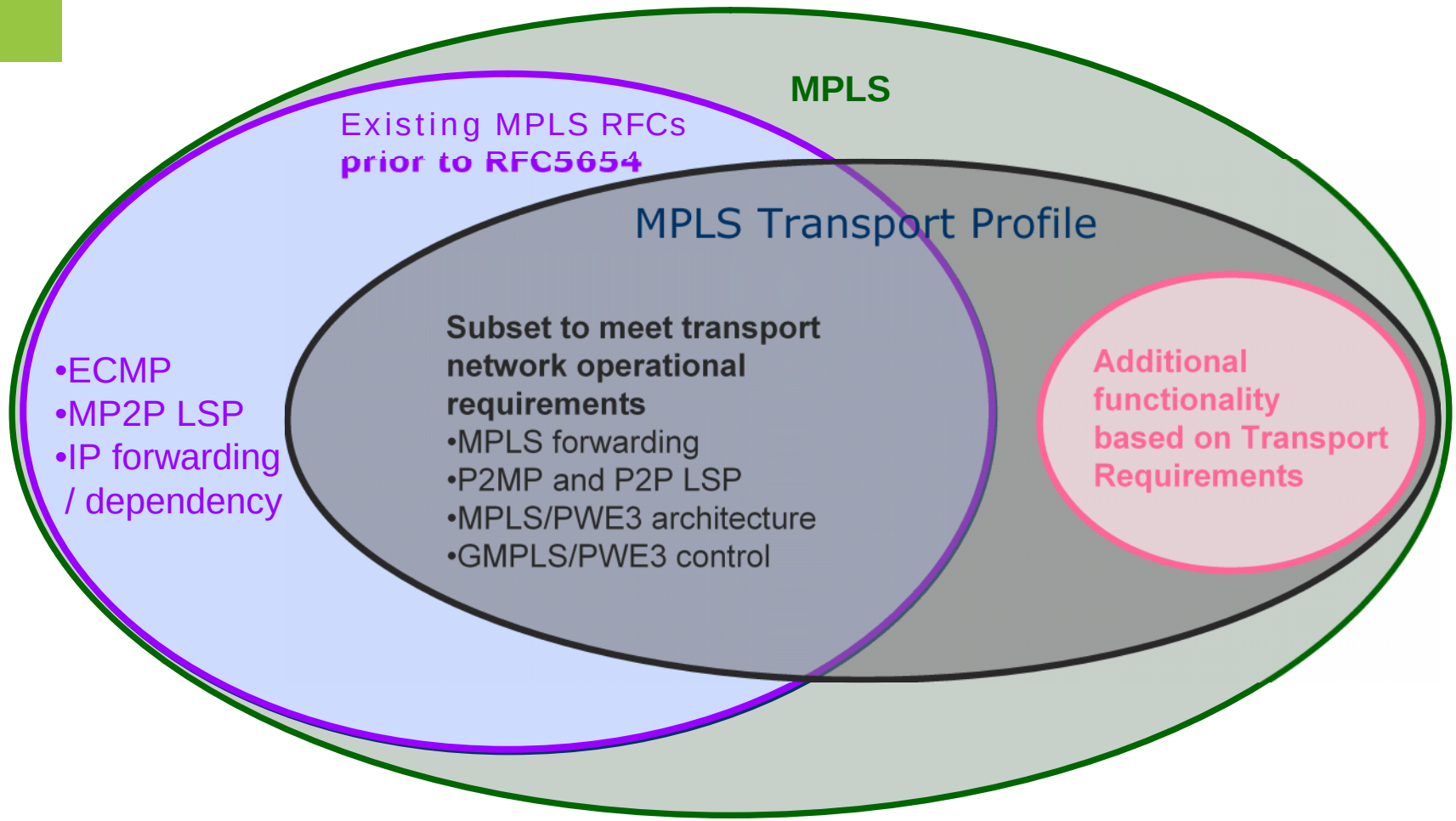
Enable connection-oriented packet transport based on widely deployed MPLS protocols, with transport-grade performance & operation similar to existing transport networks; ensure interoperability with IP/MPLS

Characterising Packet Transport

- Independence between transport network operation and client networks supported by the service
- Service guaranteed not to fall below agreed level regardless of the behaviour of other transport network clients
- Control/management plane isolation between networks using service and underlying transport network
- Little or no coordination required between client using service and underlying transport network
- All packets of any client network transparently transported
- Transport network server layer addressing and topology info hidden from client of packet transport service

(Paraphrased from RFC 5921)

What is MPLS-TP?



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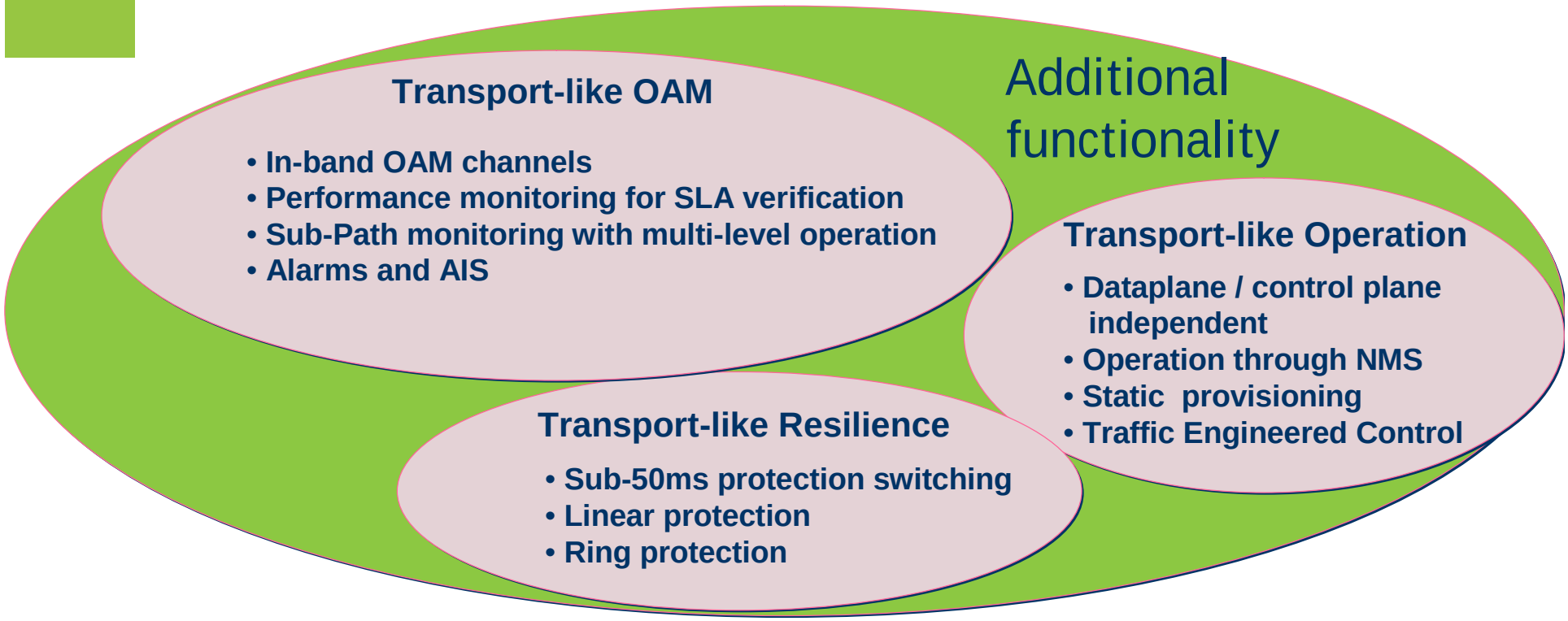
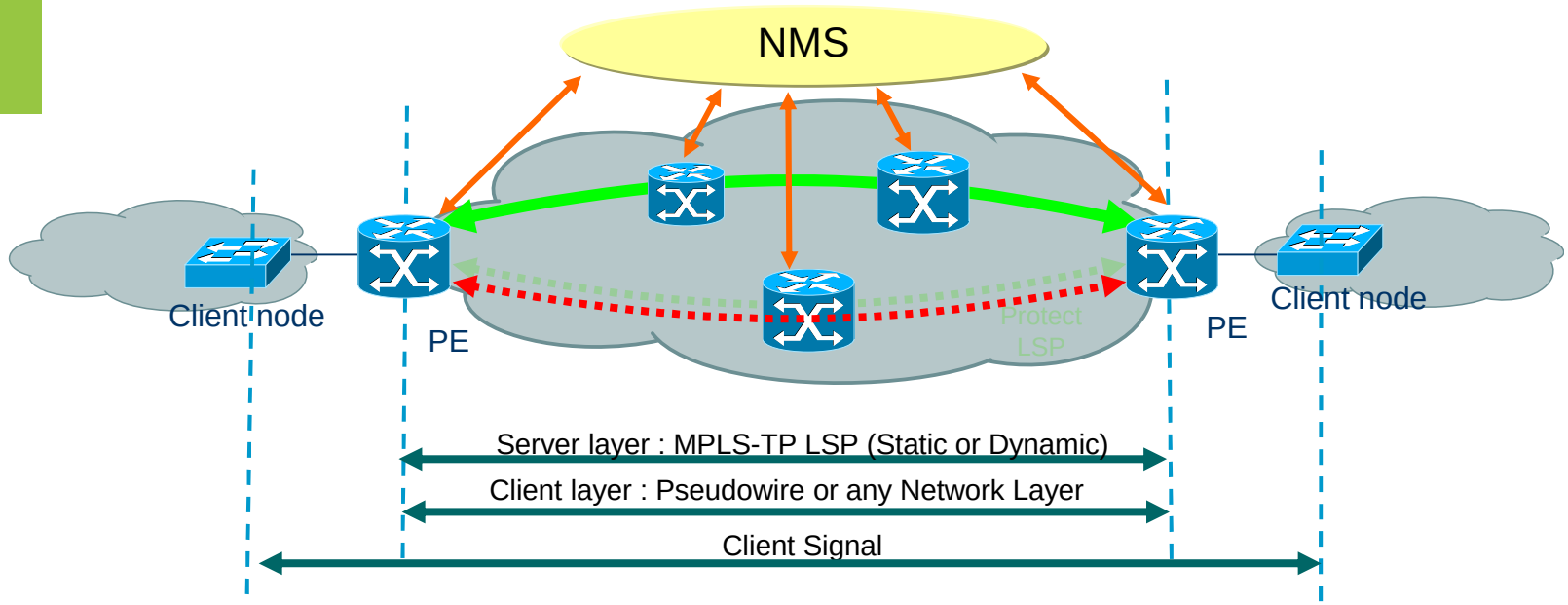
Additional Functionality based on Transport Requirements



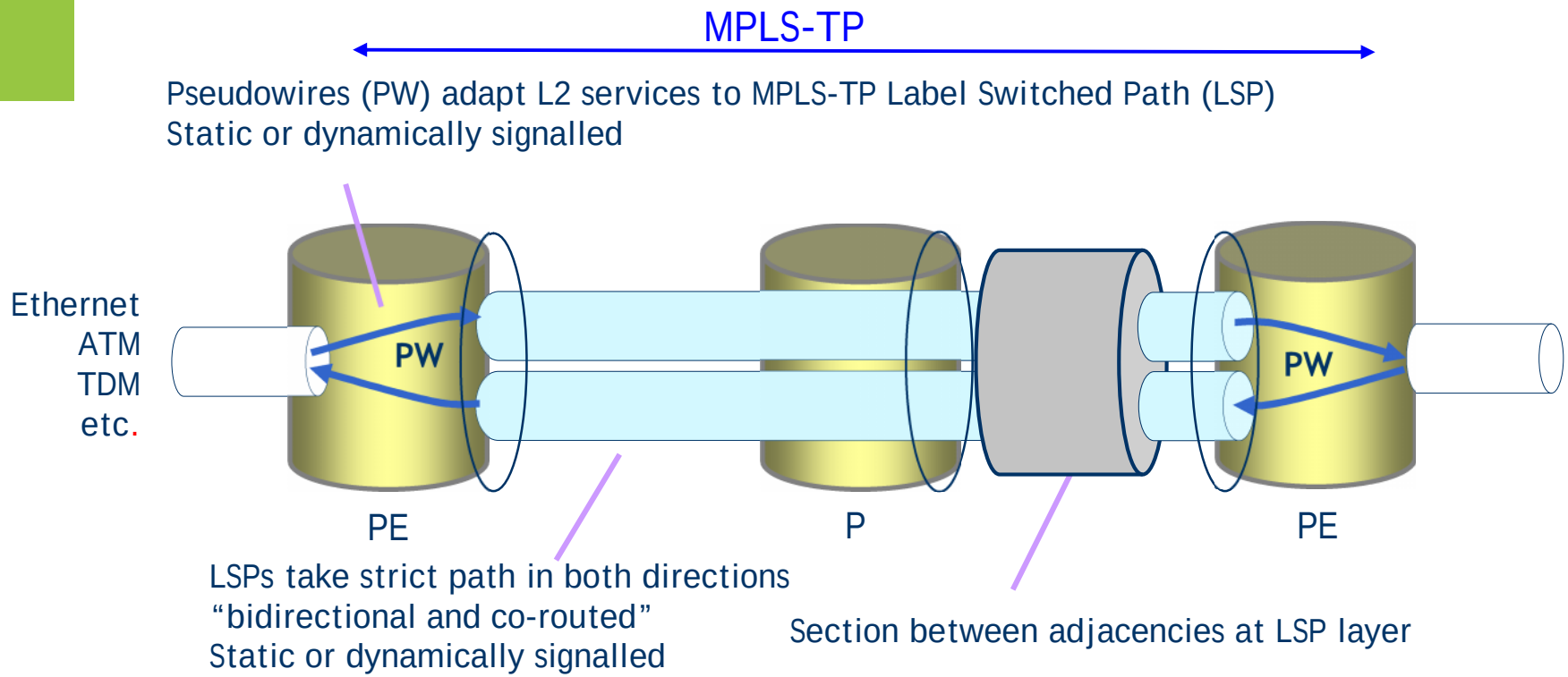
Additional features for standard IP/MPLS routers & Optical Packet Transport equipment; enhanced commonalities between service routing and optical transport

MPLS-TP architecture



- Foundation for Optical Transport equivalent OAM and protection-switching capabilities
- A centralized control/management plane with or without support of a distributed control plane
- Enables differentiation of specific packets (OAM,Automatic Protection Switching (APS), etc) from user packets
- Primary constructs are
  - MPLS LSPs for transportation (RFC3031) for Server Layer
  - Uses PWE3 architecture (RFC3985) if client Layer of an MPLS-TP LSP uses pseudowires
  - Client Layer of MPLS-TP LSP can also be 'any network layer'

MPLS-TP Architecture: Point to Point Service using PWE3



Reuse of MPLS architecture to meet transport requirements

MPLS-TP LSP

PW

Section : next higher order server layer that provides multiplexing of MPLS-TP entities such as MPLS-TP LSPs

Bidirectional MPLS-TP LSPs paring relationship

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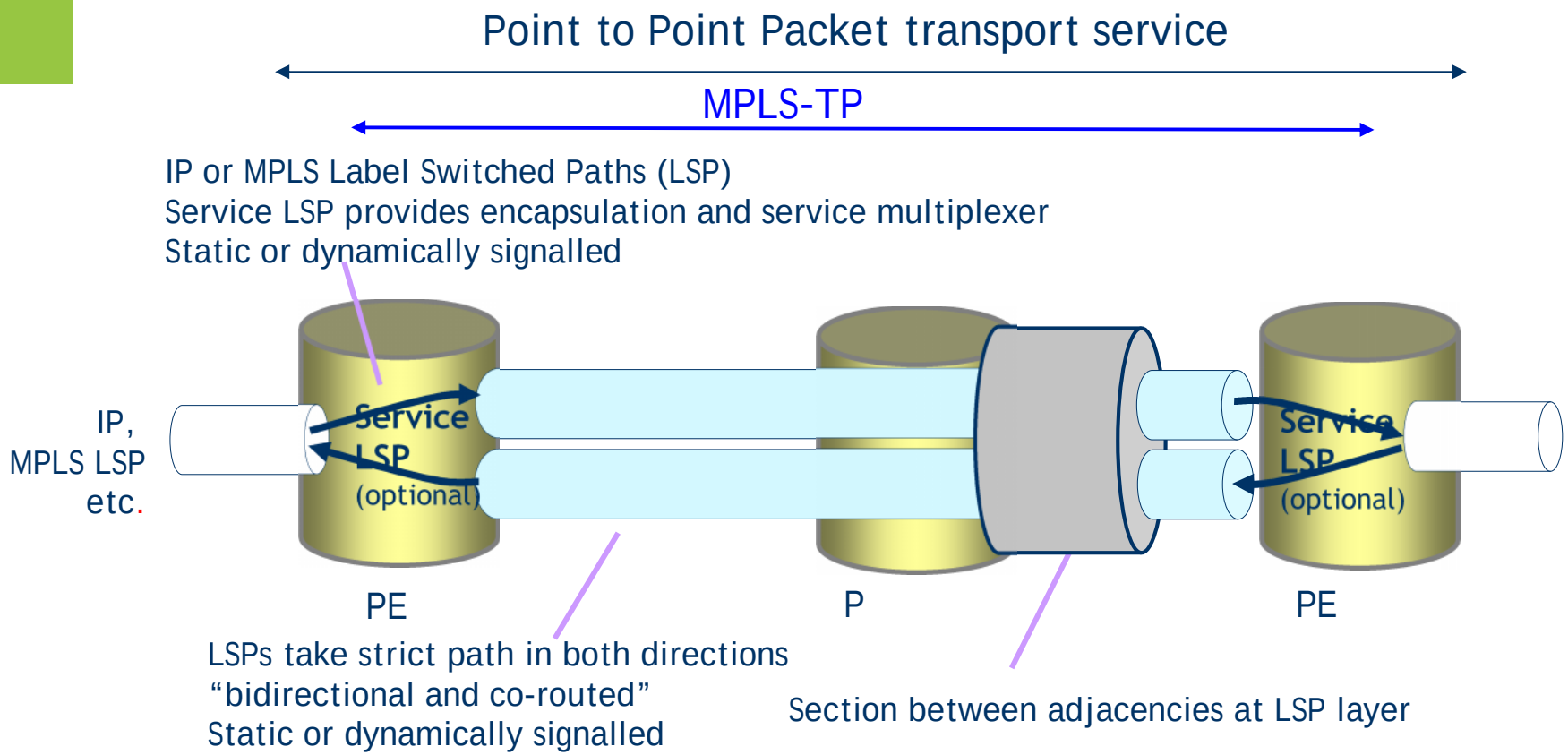
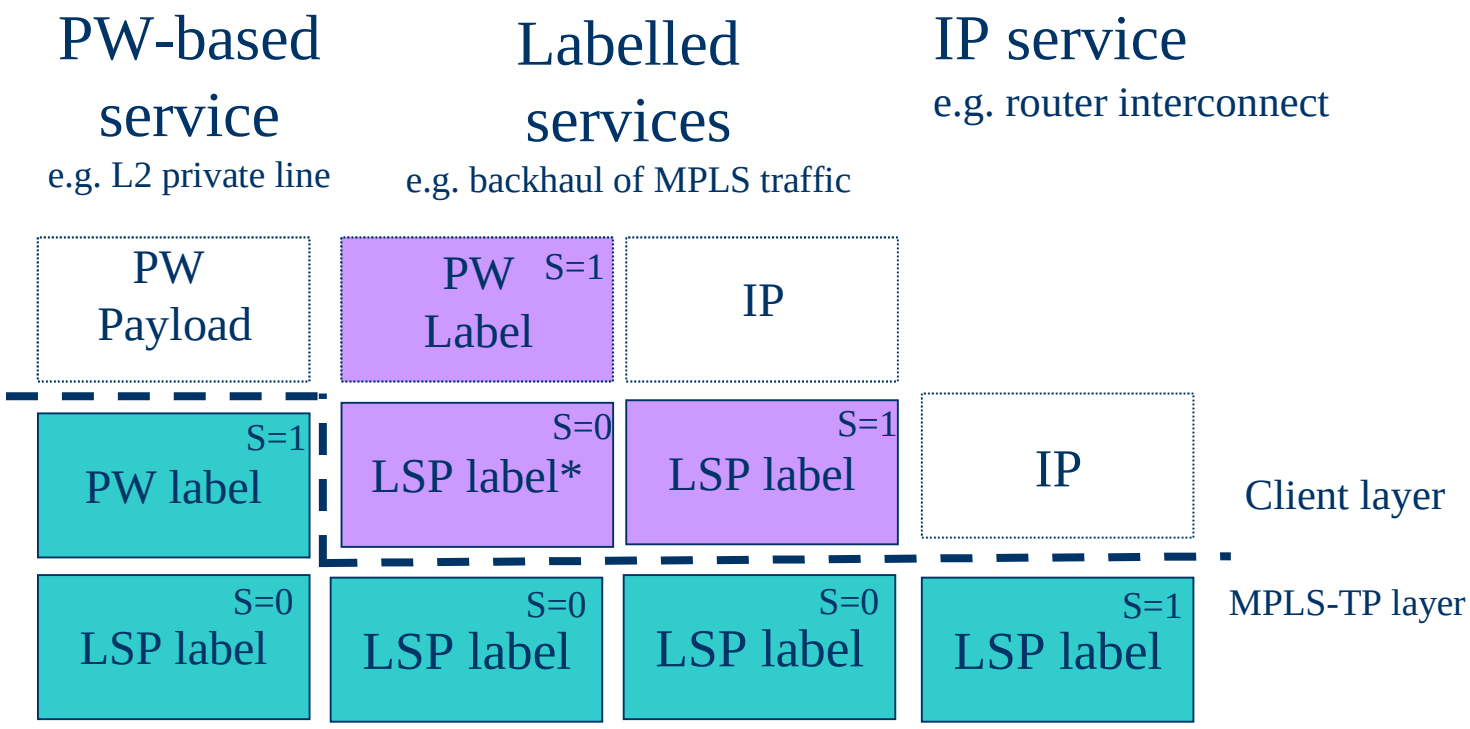
MPLS-TP Architecture: Point to Point Service for a Network Layer Client



Reuse of MPLS architecture to meet transport requirements

Domain of MPLS-TP

Where does MPLS-TP end, and client layers begin?



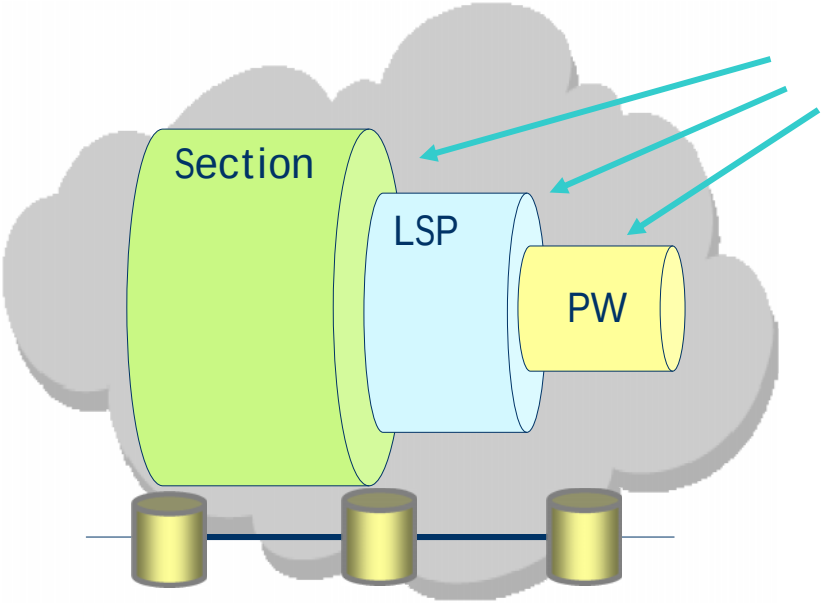
- S-bit follows current MPLS practice i.e., indicates non-MPLS follows
- Label stacks shown are the smallest number of labels possible

*Can be Penultimate Hop Popped

Enabling Enhanced OAM Capabilities

Three possibilities for OAM supported by MPLS

1. Hop-by-hop (e.g. control plane based)
2. Out-of-band OAM
3. In-band OAM similar to transport model selected for MPLS-TP



RFC5586 – Generic Associated Channel (GACh) generalises Pseudowire ACh to also enable OAM on MPLS LSPs & Sections

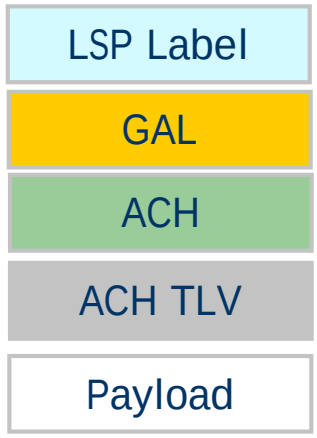
- In-band forward and return path
- Increases range of OAM tools
- Common tools at PW, LSP and Section level

Reuse of MPLS PW OAM architecture to meet transport requirements

G-ACh Label Stack for an LSP

MPLS-TP uses a new alert label to identify packets on the Generic Associated Channel (G-ACh)

– Generic ACh Label (GAL)



Generic Associated Channel Label (GAL)

- Identifies G-ACh packet
- New reserved label (Value = 13)
- Not needed for PWs — use control word

Associated Channel Header (ACH)

- Reuse PW ACH on LSPs ; same format and version number as is today
- Channel Type indicates protocol (support for IETF standard and experimental protocol)

ACH TLVs (optional — depends on ACh protocol)

- Intended for src/dst addressing, authentication, etc.

G-ACh Packet Payload

- E.g. OAM, Data Communication (DCC), protection protocols, etc.

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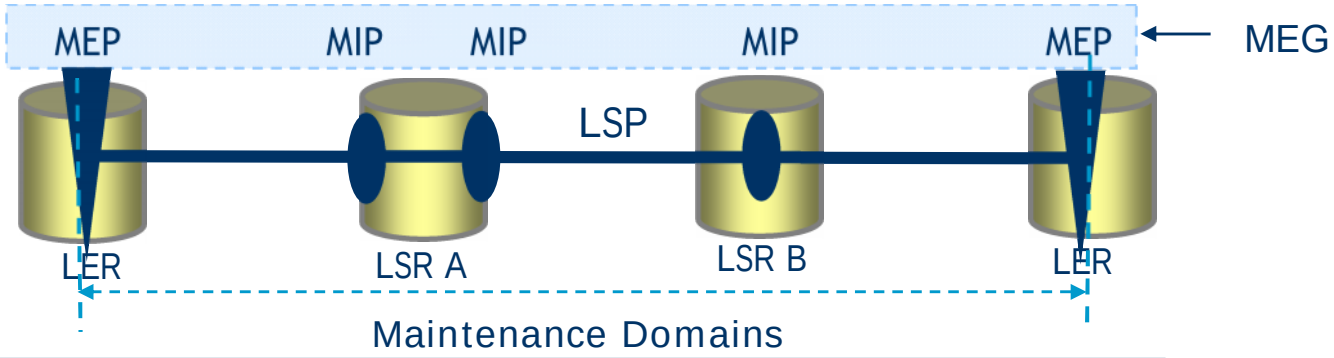
Maintenance Domains for MPLS-TP OAM

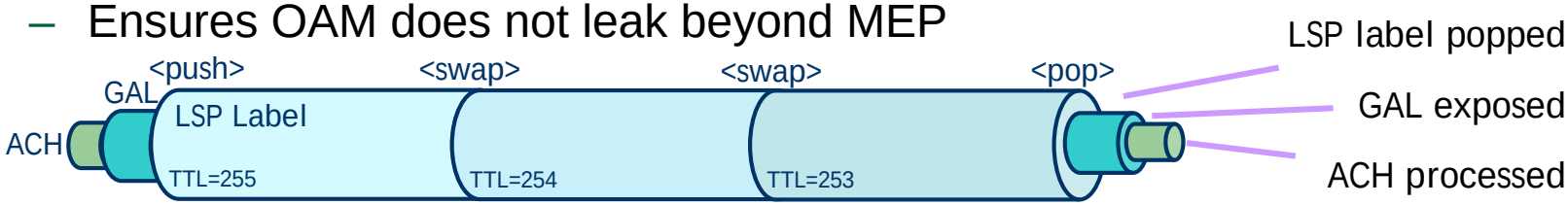
- MPLS-TP uses concept of Maintenance Domains being managed/monitored
- Maintenance End Points (MEPs) are edges of a maintenance domain
  - OAM of a maintenance domain must not leak beyond corresponding MEP
- Maintenance Intermediate Points (MIPS) are intermediate elements that can be monitored
- Maintenance Entity Groups (MEGs) comprise all the MEPs and MIPs on a given maintenance domain for a pseudowire, LSP, or section.



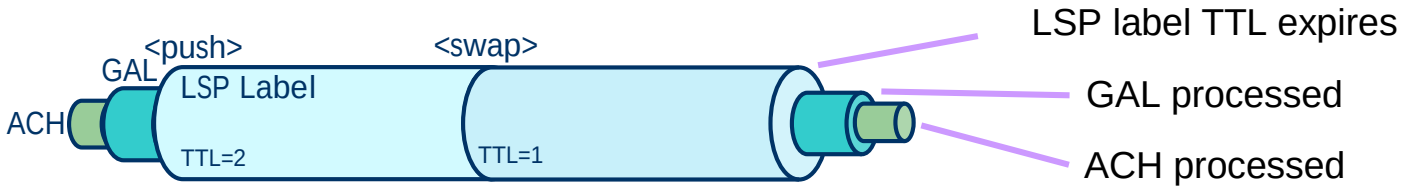
MPLS-TP introduces transport OAM concepts to MPLS
Aligns management of packet and circuit based transport

Targeting OAM to a MEP or MIP

- Verification that OAM message received at targeted MIP/MEP for further processing using Destination address
- For a MEP, GAL exposed when label popped
  - Ensures OAM does not leak beyond MEP



- For a MIP, TTL expires, force OAM packet to be processed



MPLS-TP uses common MPLS mechanisms to achieve transport-oriented functions

OAM Function: Requirements RFC 5860

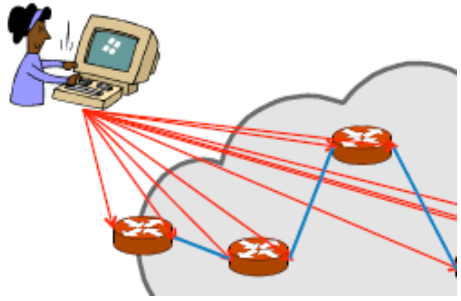
- **Pro-active monitoring features**
  - Continuity supervision (Integrity)
  - Connectivity supervision
  - Signal quality supervision (packet loss)
  - Alarm suppression (Silencing)
  - Single-ended maintenance
- **Pro-active monitoring applications**
  - Fault management
  - Performance monitoring
  - Protection switching
- **Re-active/On-demand monitoring**
  - Fault localization
  - Signal quality measurement
    - Throughput
    - Ordering and error
    - Transfer delay and jitter
- **Communication channels**
  - Protection switching head/tail-end coordination
  - Network control and management
  - Remote node management
  - Service management

- IETF approach is to reuse or extend existing tools as far as reasonable or develop new tools when needed
- Note: the tools meeting the requirements above are still under development in the IETF, and may be discussed in a next version of the tutorial.

Management and Control for MPLS-TP

"MPLS-TP transport paths may be established using static or dynamic configuration. It should be noted that the **MPLS-TP network and its transport paths can always be operated fully in the absence of any control plane."**[1]

- The PW control plane is based on the existing PW control plane (LDP), see [RFC4447].
- The LSP control plane is based on Generalized MPLS (GMPLS), see [RFC3945].
- Plug-and-play Signalling Communication Channel (SCC) over LSPs or sections for signaling in absence of native IP support in server layer

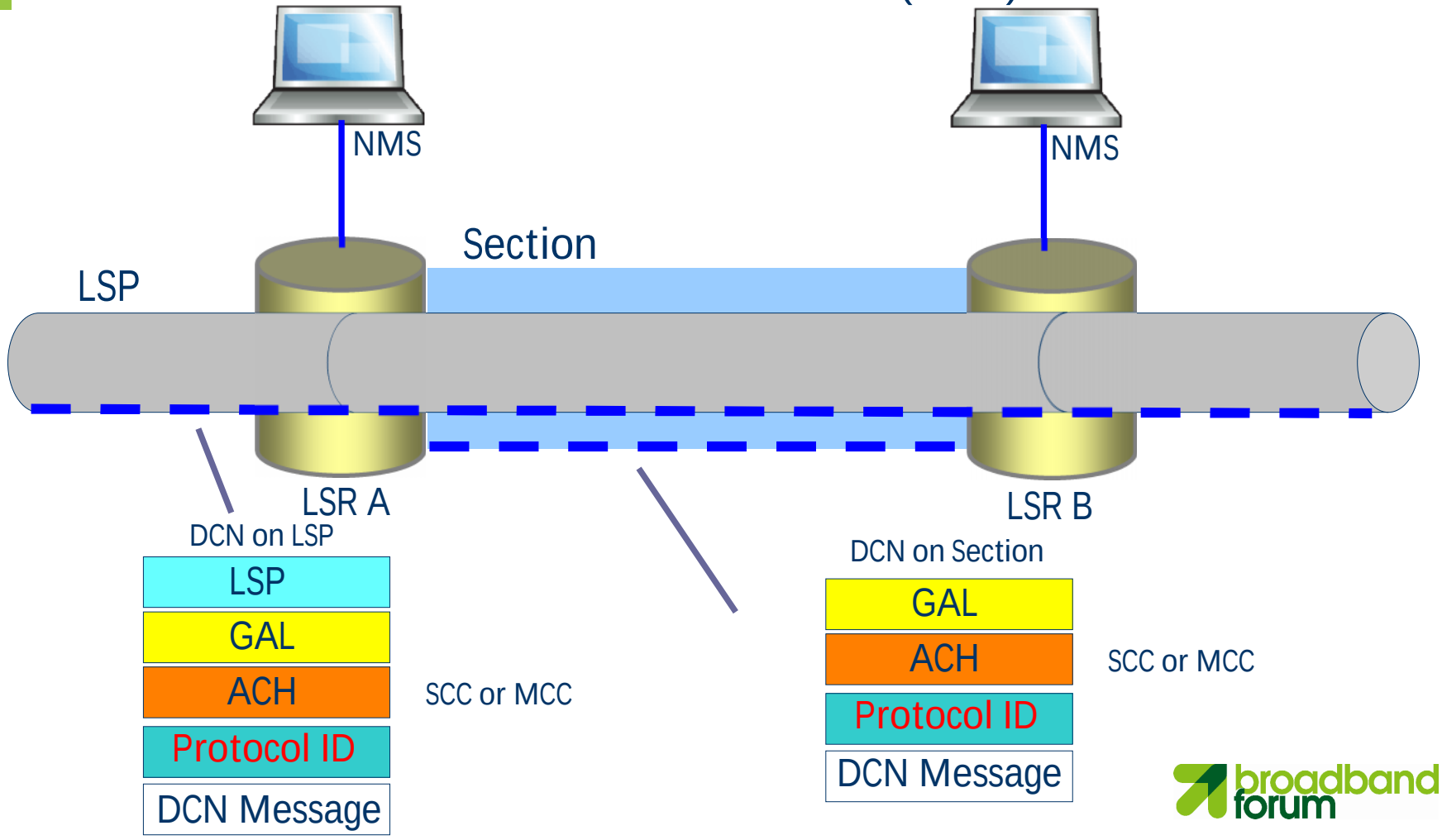


- Done via **management plane**.
- "Static provisioning MUST NOT depend on the presence of any element of a control plane."[1]
- Plug-and-play Management Communication Channel (MCC) over G-ACh can carry NMS traffic

[1]: RFC5654

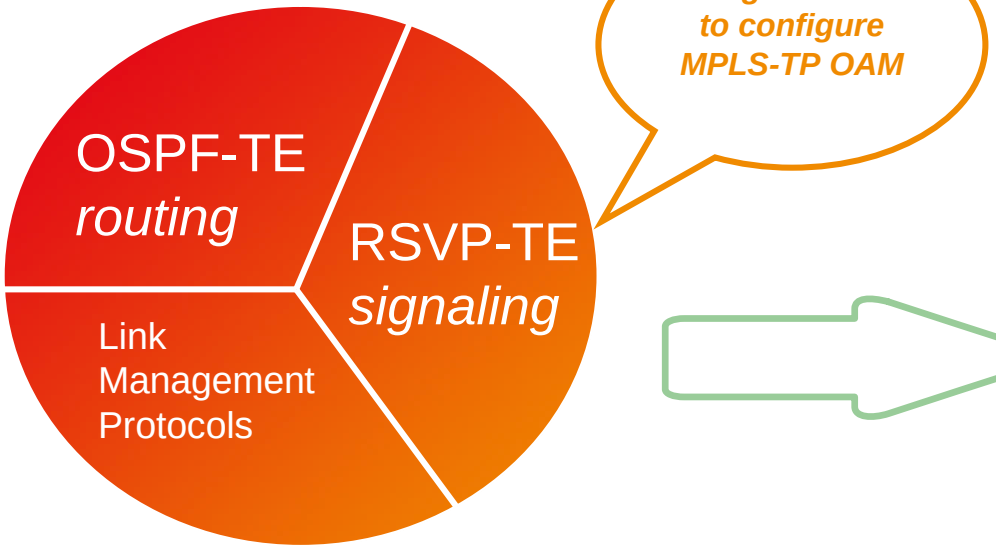
Data Communication Network using Generic Associated Channel (G-ACh)

Carries Management Communication Channel (MCC) or Signalling Communication Channel (SCC)



GMPLS for MPLS-TP LSP

GMPLS is a unified, generalized distributed control plane used for multiple networking technologies and suitable for bidirectional paths



Being extended to configure MPLS-TP OAM

allows the separation of data plane and control plane:

- out-of band signaling
- in-band signaling

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LDP for MPLS-TP PW

RFC 3036

- Label Distribution Protocol (LDP) is a protocol defining how LSRs establish LSPs through a network by mapping network-layer routing information directly to data-link layer switched paths.
- LDP associates a Forwarding Equivalence Class (FEC) with each LSP it creates.

RFC 4447

LDP Universally deployed today for PW

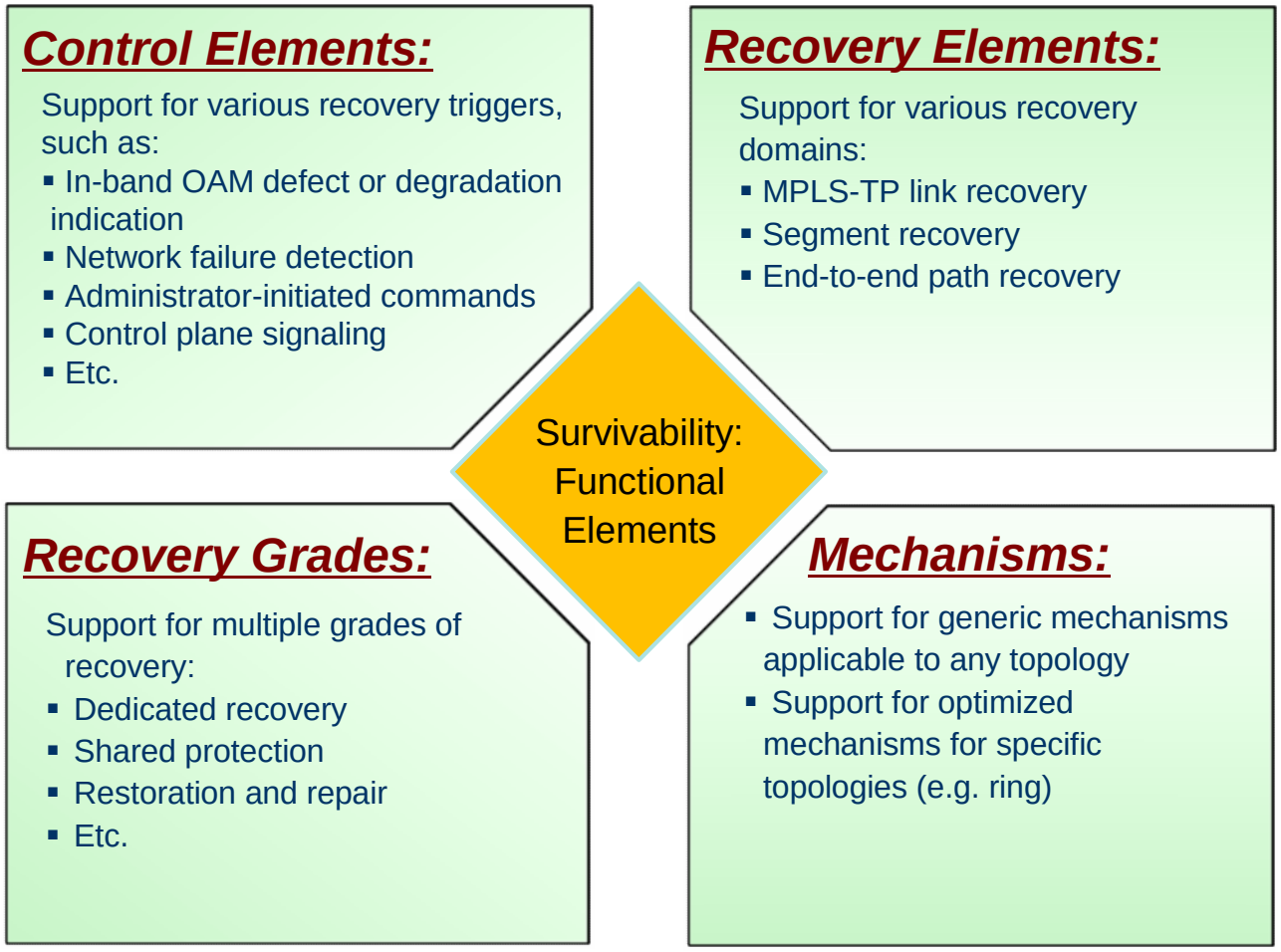
- Lightweight protocol allows for service scalability
- Signals binding of PW label to FEC
- Use enhanced pseudowire addressing with MPLS-TP
  - Global Identifier + Node Prefix + Attachment Circuit Identifier
  - Allows PW routing scalability with aggregation and domain partitioning

- **Signaling Pseudowire (PW) Status**
- **PW Status Negotiation Procedures**
- **Setup of PWs**
- **Encapsulation negotiation**
- **Supports bidirectional, co-routed PWs**

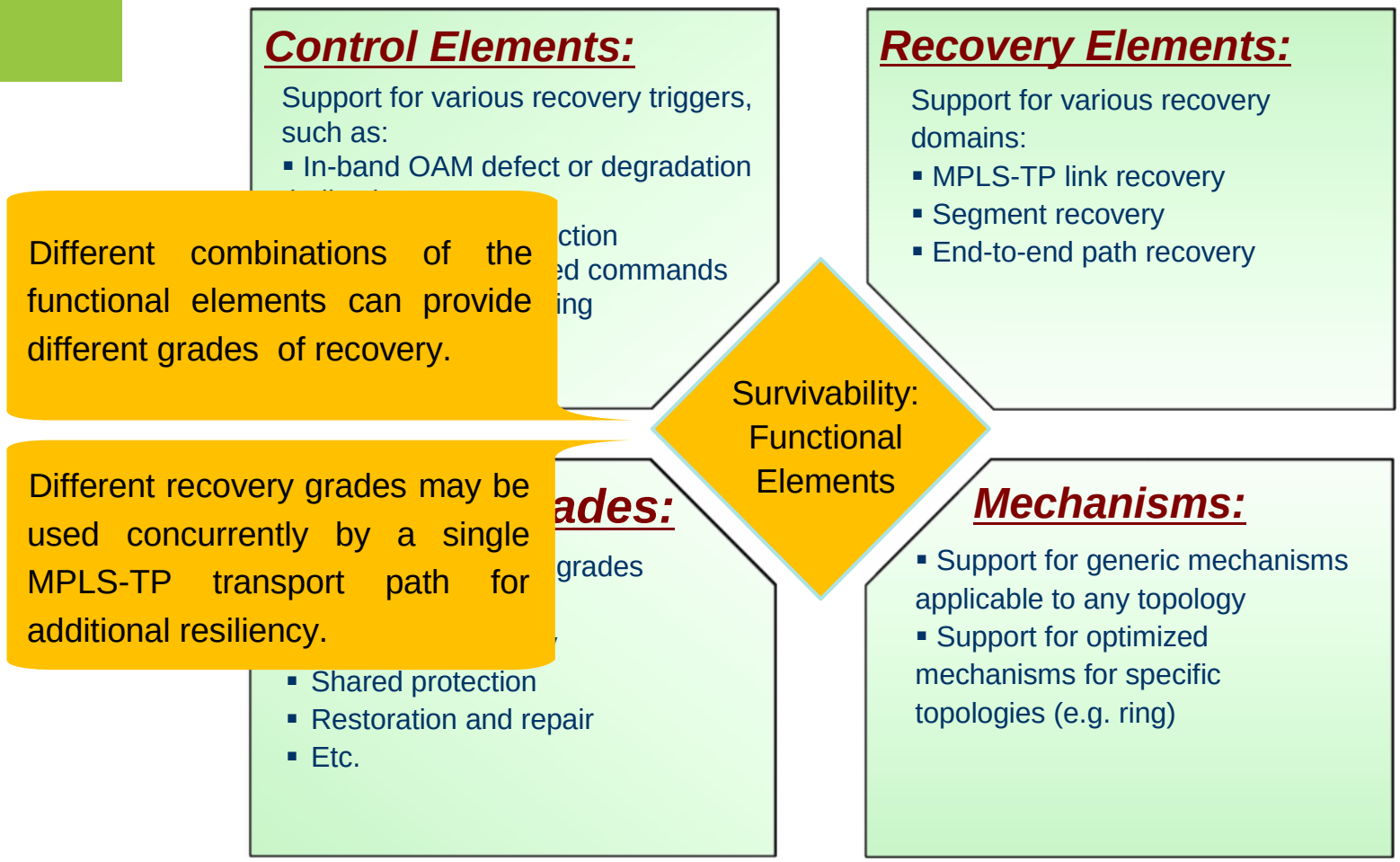
MPLS-TP Survivability Objectives

- Survivability is the network's ability to restore traffic and recover from "failed" or "degraded" entities (links or nodes). It is critical for the delivery of *reliable services* in transport networks.
- MPLS-TP to support a comprehensive set of recovery mechanisms at different nested levels (i.e., the end-to-end level of a transport path, a path segment, and an MPLS-TP link) including:
  - Protection switching mechanisms that are appropriate for transport networks, capable of providing the recovery time required to maintain customer SLAs, by pre-provisioned active and backup paths.
  - Network restoration mechanisms controlled by a distributed control plane or a management plane, allowing to establish a backup path when the failure occurs.

MPLS-TP Survivability Functional Elements



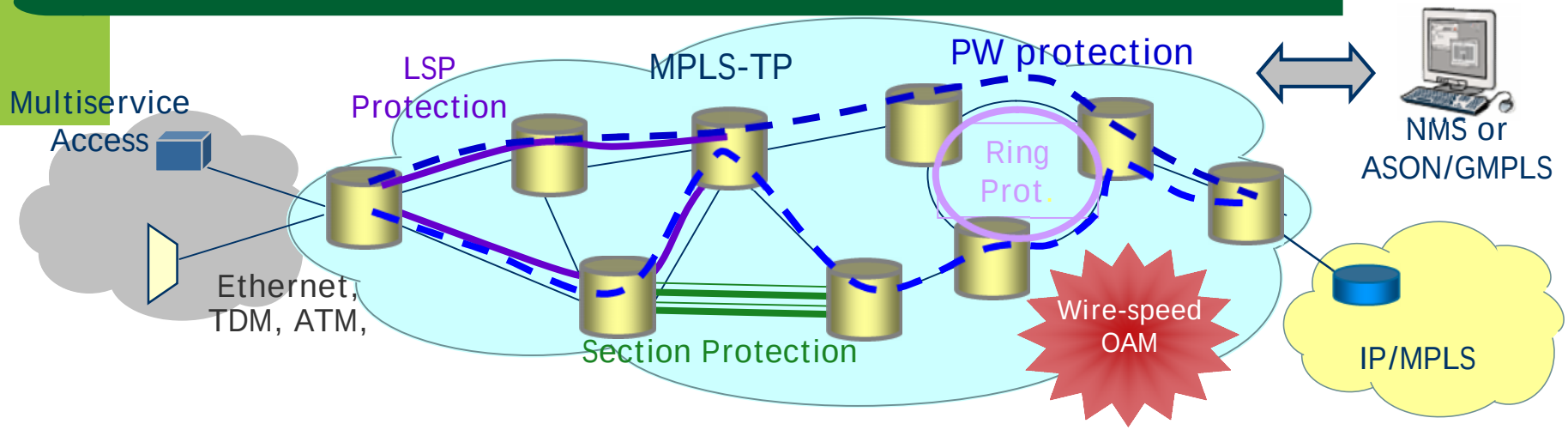
MPLS-TP Survivability Functional Elements



Different combinations of the functional elements can provide different grades of recovery.

Different recovery grades may be used concurrently by a single MPLS-TP transport path for additional resiliency.

MPLS-TP Survivability Mechanisms



Protection (data plane)

- < 50ms with protection coordination protocol triggered by data-plane OAM
- 1+1, 1:1, 1:N, without extra traffic
- Unidirectional, Bidirectional
- Section, LSP, PW
- Subnetwork Connection (SNCP)
- Mesh and Ring

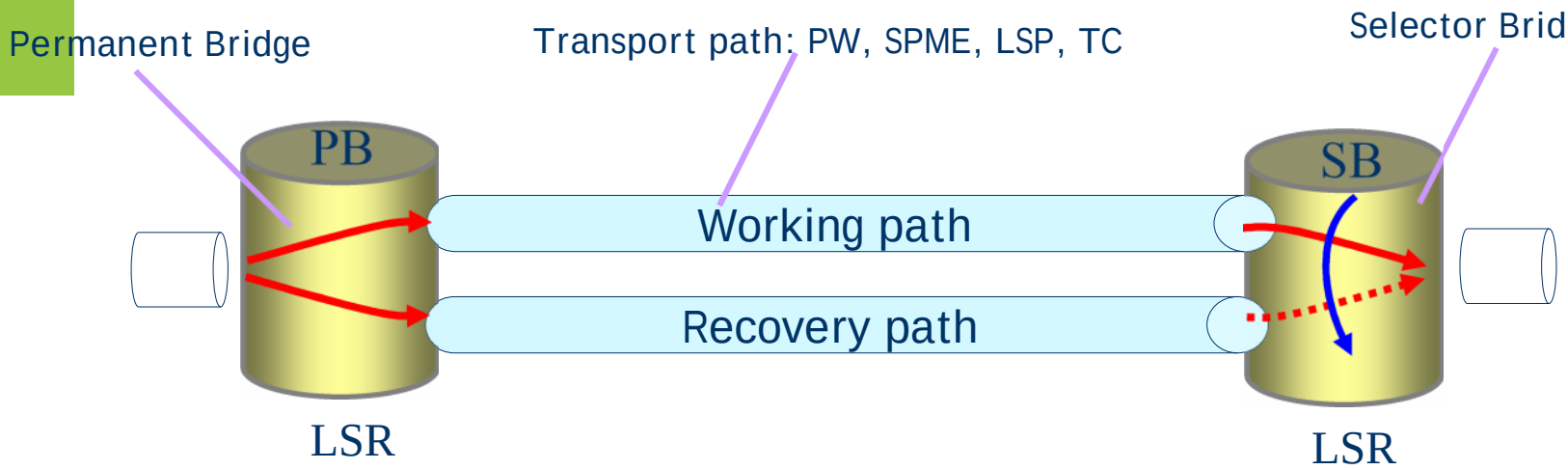
Restoration (ctrl. and mgmt. plane)

- GMPLS based restoration for LSP in synergy with other transport network technologies (SONET/SDH, OTN/WDM)
- PW redundancy
- LSP fast reroute
- GMPLS segment and end-to-end protection
- Pre-planned LSP rerouting restoration
- Any topology

MPLS-TP Recovery Mechanisms

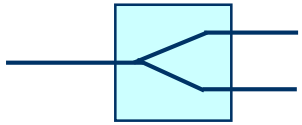
- All GMPLS and MPLS mechanisms are applicable in MPLS-TP (for any topology):
  - MPLS LSP end-to-end protection
  - PW redundancy (support for dual-homed AC failure, S-PE failure in MS-PW, etc.)
  - GMPLS segment recovery
  - GMPLS end-to-end recovery
  - MPLS LSP Fast Reroute (FRR)
  - Restoration (including pre-planned LSP restoration)
- The provisioning method should be decoupled from the data plane capability of the above mechanisms.
  - The management plane is being extended enable the provisioning of the protection entities and functions.
  - A data-plane-based protocol (in-band) is being defined to coordinate the protection state between the edges of a protection domain, and thus enable bi-directional protection switching.

Data plane: Linear 1+1 protection

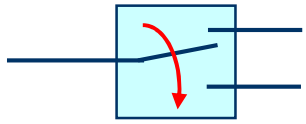


- Permanent Bridge sends traffic on both working and recovery paths
- Selector bridge selects path
- Applicable to p2p and p2mp, uni and bi-directional
- Protection coordination protocol for bi-directional, to synchronize both ends

SPME: Sub-Path Maintenance Entity
TC: Tandem Connection

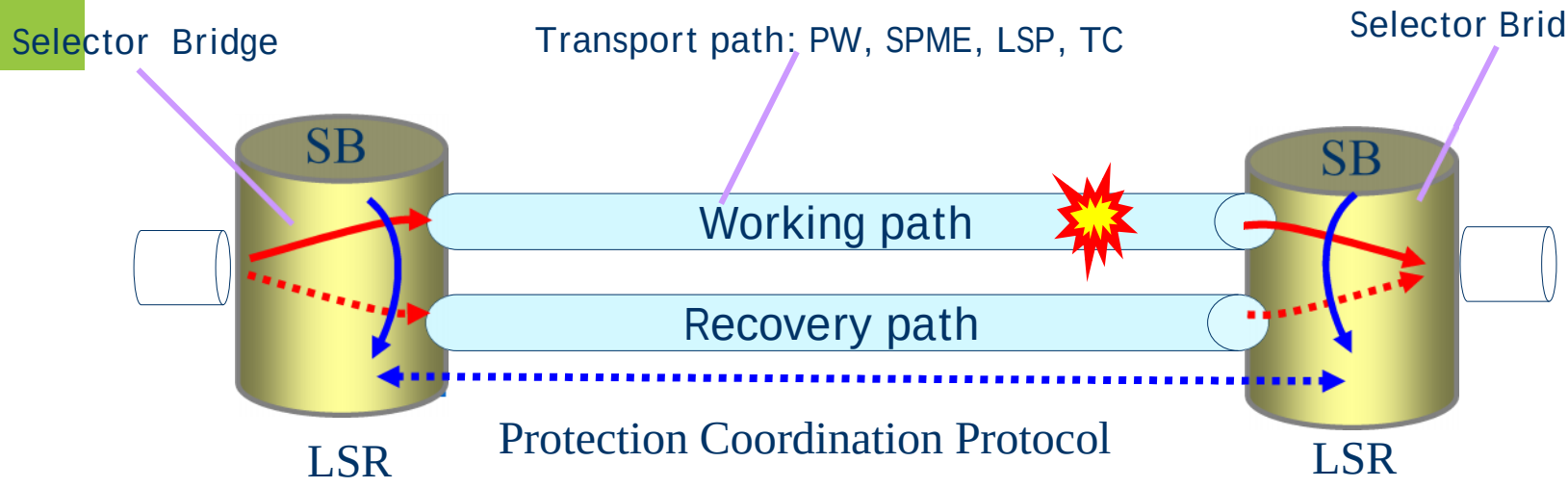


Permanent Bridge



Selector bridge

Data plane: Linear 1:1 protection



- Protection coordination protocol (PCP) for synchronization between selector bridges
- PCP messages are always sent over the recovery path over the G-ACh
- Upon failure, three control packets sent at 3.3 ms intervals to trigger switchover in sub-50ms
- Supports revertive and non-revertive, uni- and bi-directional operation

Control Plane Based Survivability

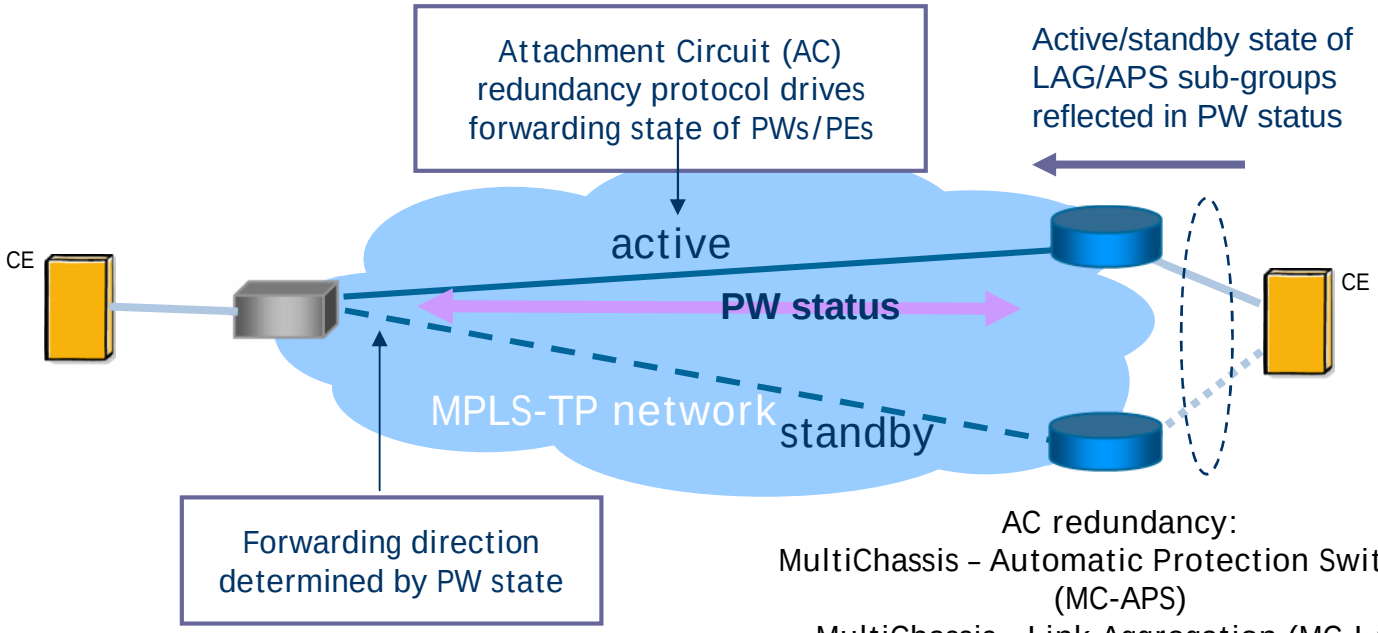
- MPLS-TP uses existing GMPLS and PW control planes
- Inherits existing control plane based survivability mechanisms applicable to uni/bi-directional paths
- LSPs: GMPLS recovery mechanisms
- PWs: PW Redundancy
  - Correct forwarding if dual-homed AC fails-over
  - Protection if S-PE fails on MS-PW

GMPLS Recovery

- GMPLS defines recovery signaling for
  - P2P LSPs in [RFC4872], RSVP-TE extensions in support for end-to-end GMPLS recovery
  - and [RFC4873] for GMPLS segment recovery.
- GMPLS segment recovery provides a superset of the function in end-to-end recovery[1].
  - All five of the protection types defined for recovery are applicable to MPLS-TP.
    - 1+1 bidirectional protection for P2P LSPs
    - 1+1 unidirectional protection for P2MP LSPs
    - 1:n (including 1:1) protection with or without extra traffic
    - Rerouting without extra traffic (sometimes known as soft rerouting), including shared mesh restoration
    - Full LSP rerouting

[1]Use of Notify messages to trigger recovery is not required in MPLS-TP as this is expected to be supported via OAM. However, it's use is not precluded.
The restoration priority and The preemption priority are supported

Regarding Pseudowire Redundancy



MPLS-TP component of end-to-end protection against PE/AC failures

- **PE configured with multiple pseudowires per service with multiple end-points**
- **Local precedence indicates primary PW for forwarding if multiple PWs are operationally UP**
- **PW status exchanged end-to-end to notify PEs of operational state of both PWs & ports/attachment circuits (PW Status Notification).**
- **Leverages Associated Channel or T-LDP**

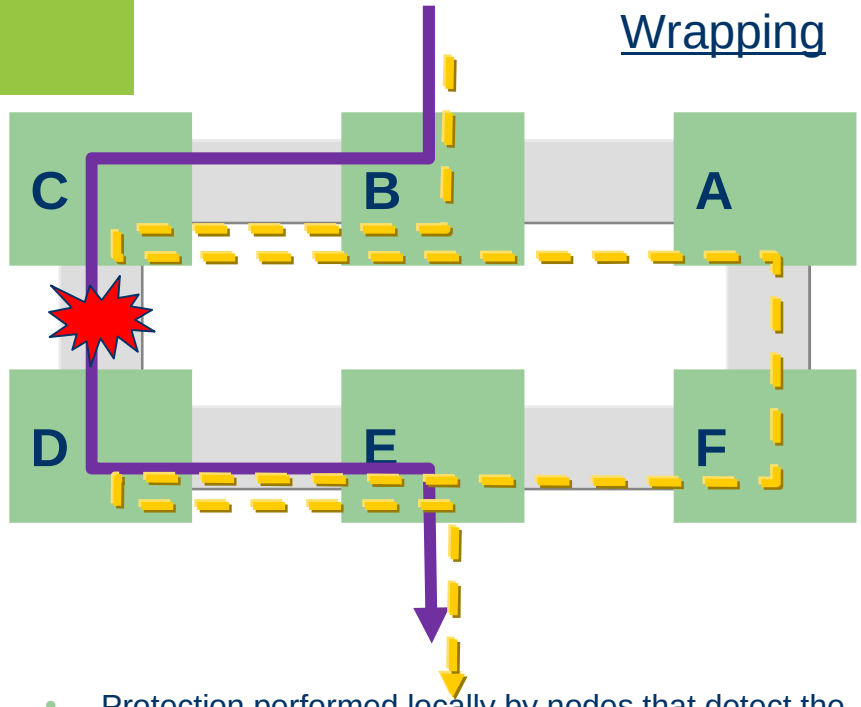
Ring protection: Background

- Physical rings are prevalent in existing carrier transport networks.
- P2mp paths are easier to implement in a ring topology.
- Ongoing work to optimize the protection operation of MPLS-TP in ring topologies. Various criteria for optimization are considered in ring topologies, such as:
  - Simplification of ring operation in terms of the number of OAM maintenance entities that are needed to trigger recovery actions, the number of recovery elements, the number of management-plane transactions during maintenance operations
  - Optimization of resource consumption around the ring, such as the number of labels needed for the protection paths that traverse the network, the total bandwidth required in the ring to ensure path protection

Variants of Ring Protection

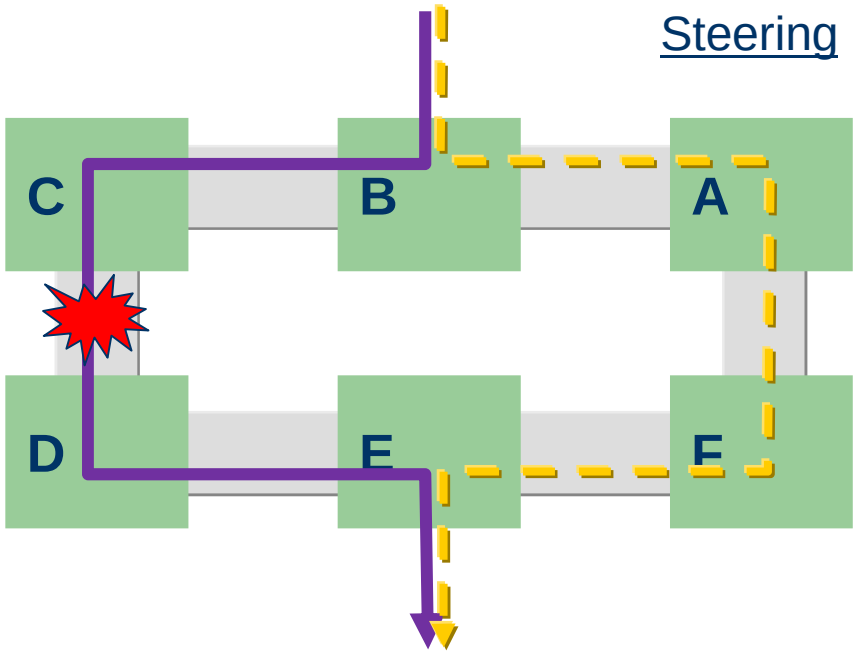
Typical options

Wrapping



- Protection performed locally by nodes that detect the fault
- Does not require knowledge of the path followed by an LSP at the ring ingress/egress nodes
- Wrapping adds latency during protection switching conditions

Steering



- Protection performed by the ring ingress/egress nodes for the LSPs affected by the fault
- Requires knowledge of the path followed by an LSP at the ring ingress/egress nodes
- Steering minimizes latency and bandwidth usage during protection switching conditions

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QoS for MPLS-TP

- MPLS-TP data plane is a subset of the existing MPLS data plane: therefore the QoS capabilities are the same
  - MPLS based traffic management, e.g., policing, shaping, is applicable to MPLS-TP for traffic guarantees
- The Traffic Class bits (aka EXP bits) are used to determine the QoS for a packet
- QoS and SLA conformance can be measured using on-demand or pro-active performance monitoring tools
- The Traffic Class bits to be used per LSP are established via
  - provisioning or
  - dynamic signaling (GMPLS)

IETF MPLS-TP Related RFCs Published

RFC 5317	JWT Report on MPLS Architectural Considerations for a Transport Profile	02/2009
RFC 5654	MPLS-TP Requirements	09/2009
RFC 5586	MPLS Generic Associated Channel	06/2009
RFC 5462	Multiprotocol Label Switching (MPLS) Label Stack Entry: "EXP" Field Renamed to "Traffic Class" Field	02/2009
RFC 5718	An In-Band Data Communication Network For the MPLS Transport Profile	01/2010
RFC 5860	MPLS-TP OAM Requirements	05/2010
RFC 5921	A Framework for MPLS in Transport Networks	07/2010
RFC 5960	MPLS Transport Profile Data Plane Architecture	08/2010

For more information, see:
http://datatracker.ietf.org/wg/mpls/
http://datatracker.ietf.org/wg/pwe3/
http://datatracker.ietf.org/wg/ccamp/

IETF MPLS-TP Working Group Documents (1)

The following WG documents are work in progress

- **MPLS-TP Identifiers**
  draft-ietf-mpls-tp-identifiers
- **MPLS-TP Linear Protection**
  draft-ietf-mpls-tp-linear-protection
- **Multiprotocol Label Switching Transport Profile Survivability Framework** (RFC queue)
  draft-ietf-mpls-tp-survive-fwk
- **MPLS-TP Control Plane Framework**
  draft-ccamp-mpls-tp-control-plane-framework
- **MPLS-TP Network Management Framework** (RFC queue)
  draft-ietf-mpls-tp-nm-framework
- **MPLS TP Network Management Requirements** (RFC queue)
  draft-ietf-mpls-tp-nm-req
- **MPLS-TP OAM Analysis**
  draft-ietf-mpls-tp-oam-analysis
- **MPLS-TP OAM Framework**
  draft-ietf-mpls-tp-oam-framework
- **A Thesaurus for the Terminology used in Multiprotocol Label Switching Transport Profile (MPLS-TP) drafts/RFCs and ITU-T's Transport Network Recommendations**
  draft-ietf-mpls-tp-rosetta-stone

For more information, see:
http://datatracker.ietf.org/wg/mpls/
http://datatracker.ietf.org/wg/pwe3/
http://datatracker.ietf.org/wg/ccamp/

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IETF MPLS-TP Working Group Documents (2)

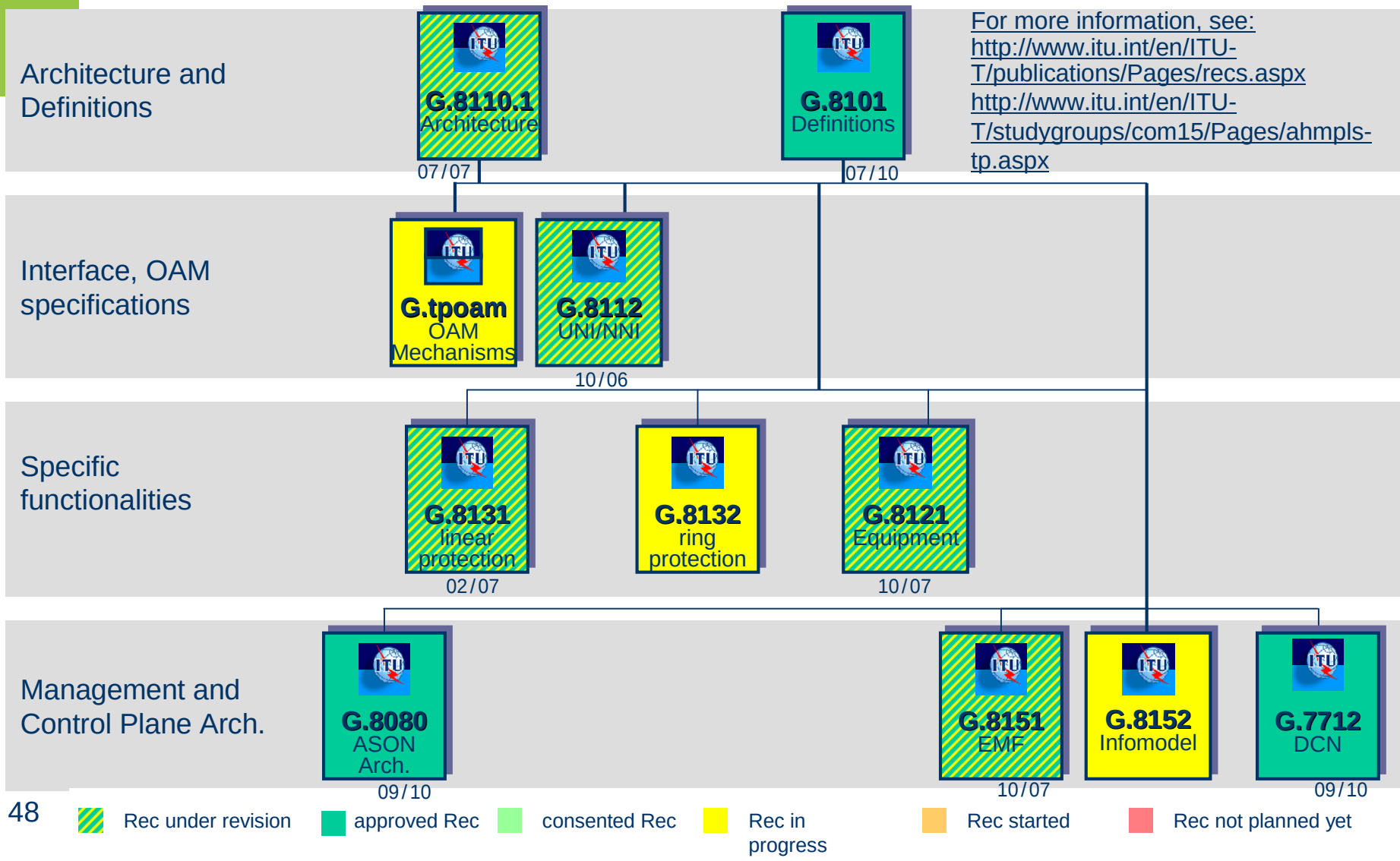
The following OAM WG documents are work in progress

- **Proactive Connection Verification, Continuity Check and Remote Defect indication for MPLS Transport Profile**
  draft-ietf-mpls-tp-cc-cv-rdi
- **MPLS on-demand Connectivity Verification, Route Tracing and Adjacency Verification**
  draft-ietf-mpls-tp-on-demand-cv
- **MPLS Fault Management OAM**
  draft-ietf-mpls-tp-fault
- **LSP-Ping and BFD encapsulation over ACH**
  draft-ietf-mpls-tp-lsp-ping-bfd-procedures
- **PW Static PW status**
  draft-ietf-pwe3-static-pw-status
- **Packet Loss and Delay Measurement for the MPLS Transport Profile**
  draft-ietf-mpls-tp-loss-delay

For more information, see:
http://datatracker.ietf.org/wg/mpls/
http://datatracker.ietf.org/wg/pwe3/
http://datatracker.ietf.org/wg/ccamp/

MPLS-TP ITU-T Standards Overview

Work in progress to align with MPLS-TP

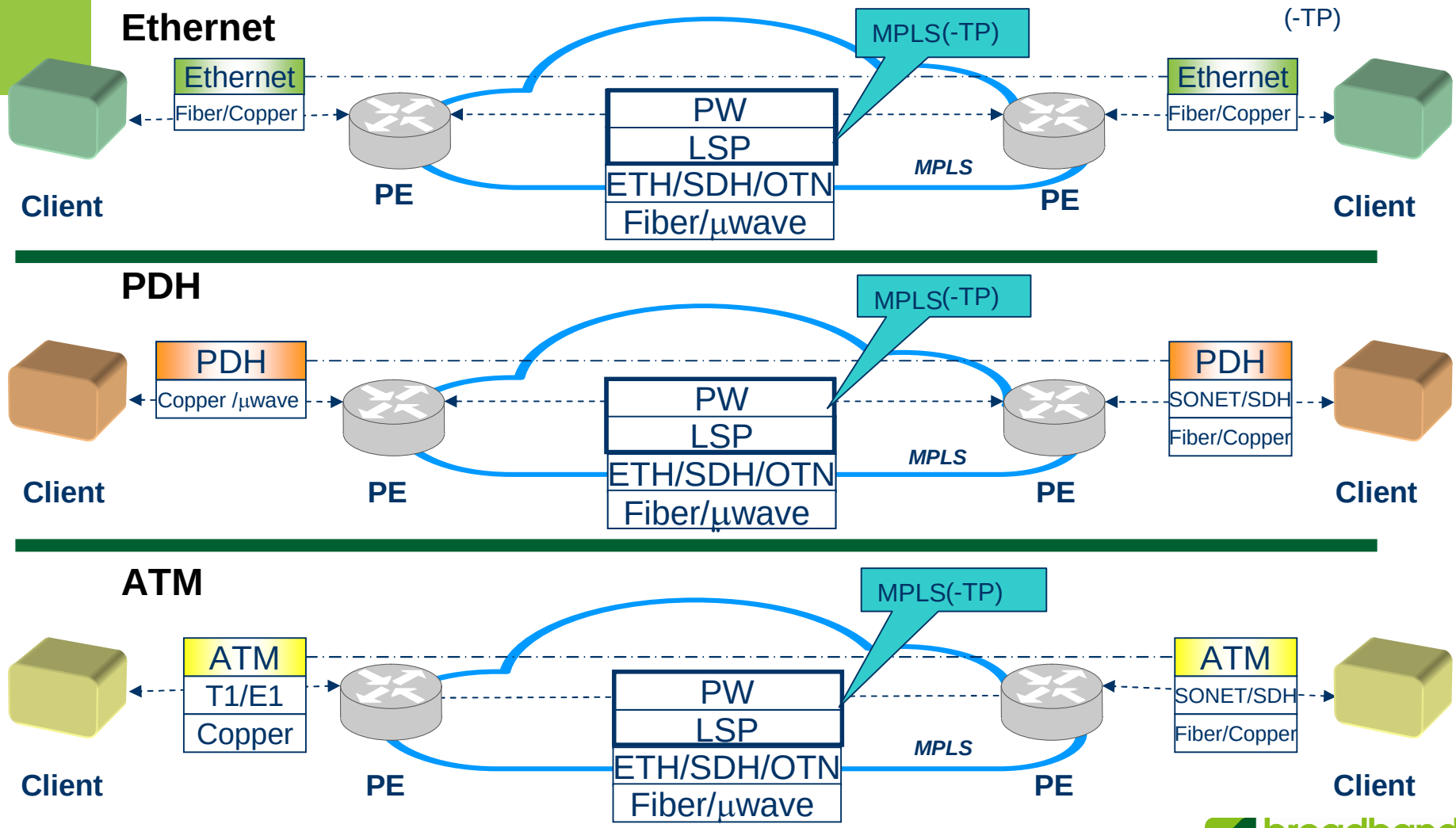


MPLS-TP Use-Cases and BBF Applicability

Use cases

- Multiple services over MPLS-TP
  - Ethernet
  - ATM
  - TDM
  - IP and/or MPLS (e.g. Router interconnect)
- Interoperability between MPLS-TP and IP/MPLS
- MPLS-TP as a client of IP/MPLS (using an IP/MPLS core to tunnel MPLS-TP LSPs)

Multiple services as a client of MPLS*(-TP*)*



(*)The Transport Profile can be used in any case where MPLS can be used
Note: SDH refers to both SONET and SDH

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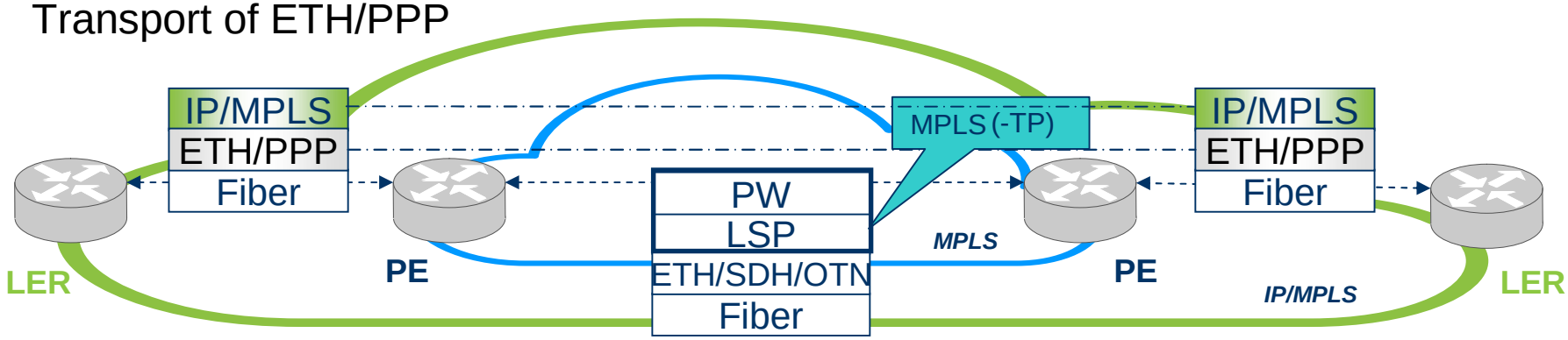
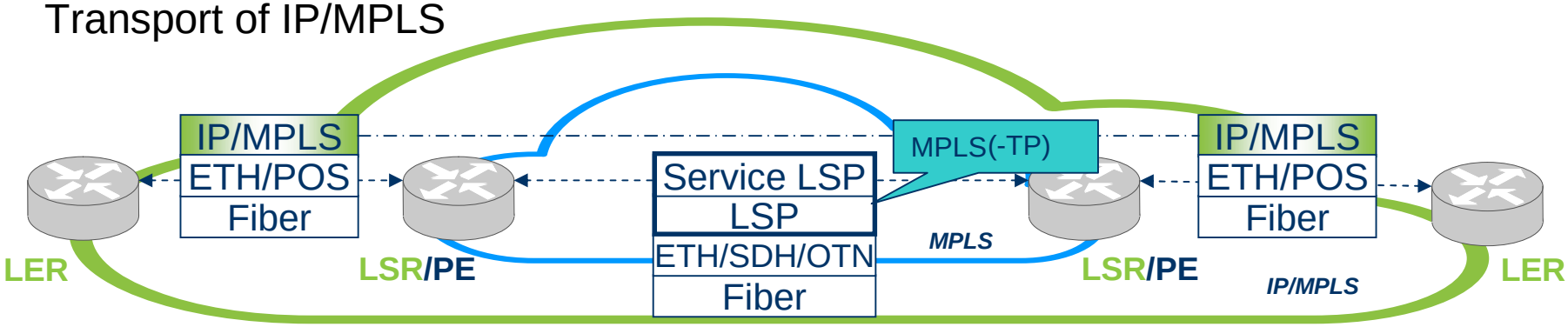
Multiple services as a client of MPLS *(-TP*)*

IP and/or MPLS (Router interconnect)

Transport of ETH/PPP



Transport of IP/MPLS

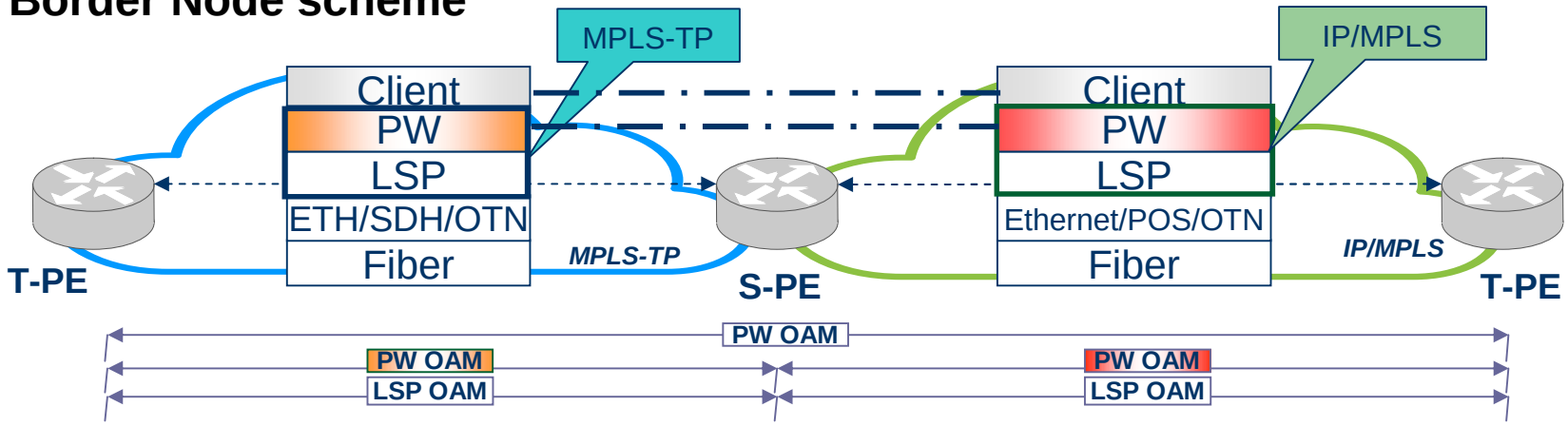


(*)The Transport Profile can be used in any case where MPLS can be used
Note: SDH refers to both SONET and SDH

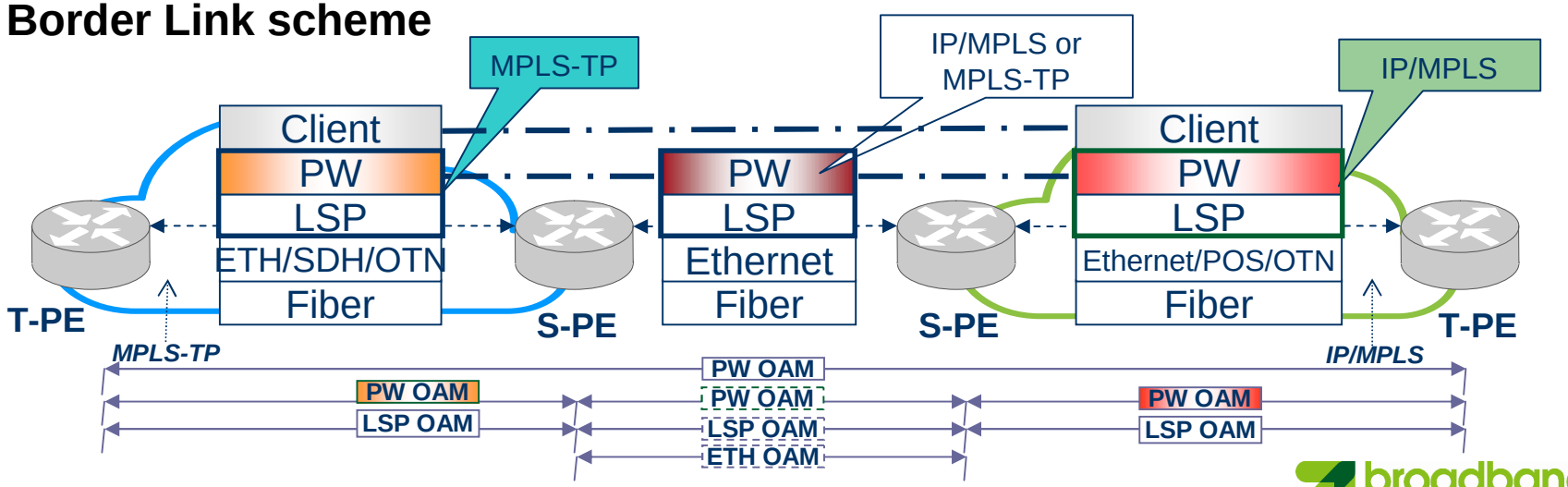
Multi-Segment Pseudowire (MS-PW)

enables interconnection between MPLS-TP and other domains
This scenario assumes IP/MPLS supporting MPLS-TP OAM, as per RFC5860

Border Node scheme



Border Link scheme



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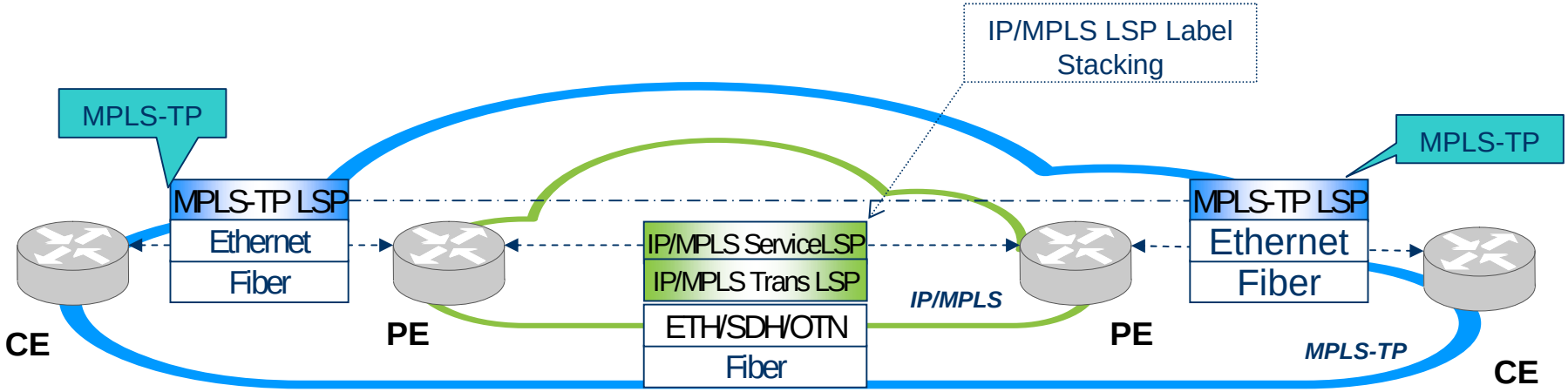
MPLS-TP as a client of IP/MPLS

IP/MPLS core tunnels MPLS-TP LSP



Notes:

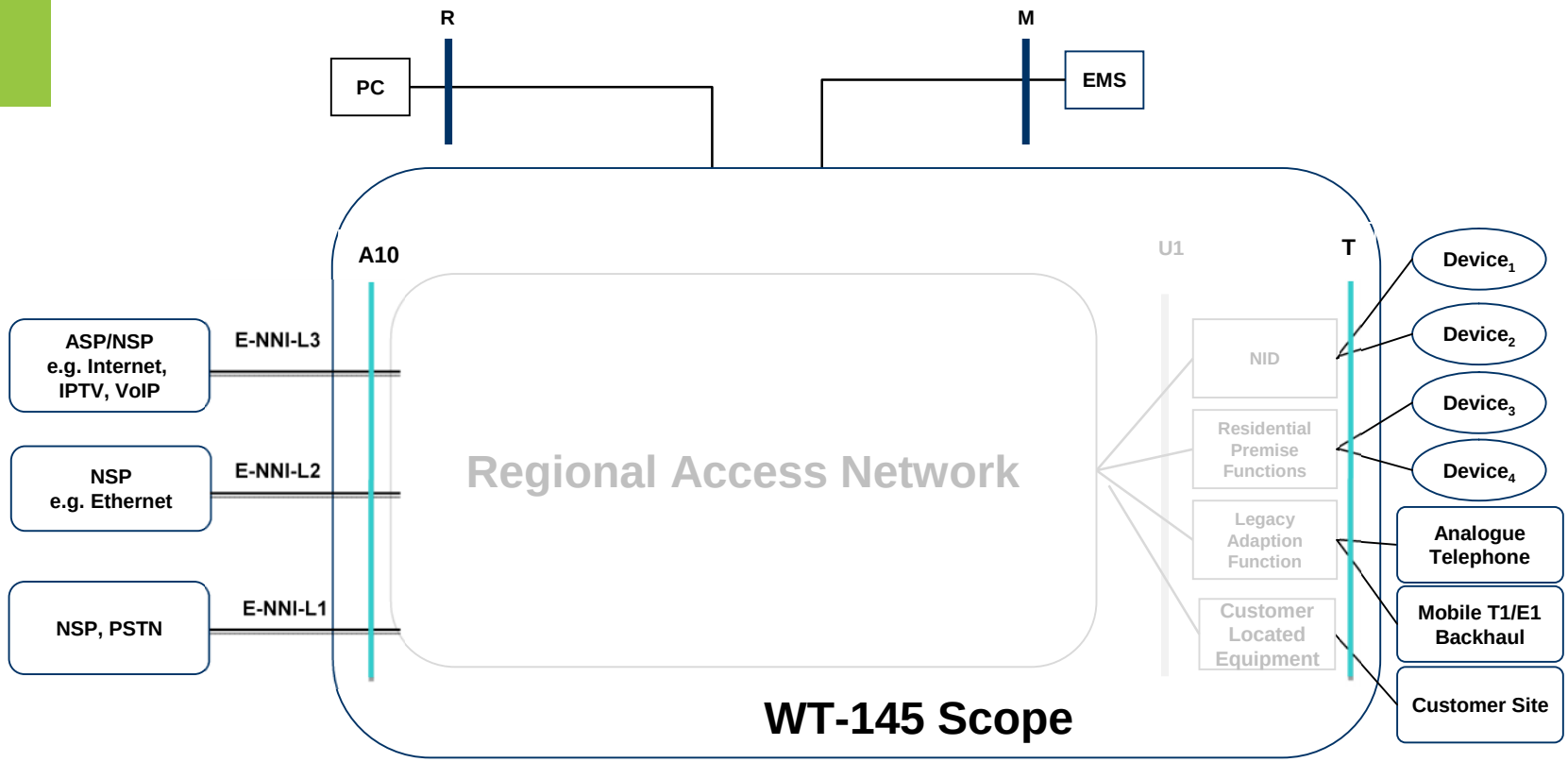
- MPLS-TP Bidirectional corouted LSPs must be ensured (TE) over IP/MPLS core
- P2P MPLS-TP LSPs over IP/MPLS core → ECMP is not used
- IP/MPLS Service LSP and Transport LSP roles may be provided by one LSP

Applicability in Broadband Forum Architectures

Use of MPLS-TP in Multiservice Broadband

WT-145, WT-178

WT-145 : Multiservice Broadband Network Functions and Architecture



WT-145 is a broadband network architecture to support multiple services including Residential Triple-Play, Business L2VPN and L3VPN, Backhaul and Wholesale Services

WT-178 provides nodal requirements for WT-145

Note: WT-145 /178 is work in progress

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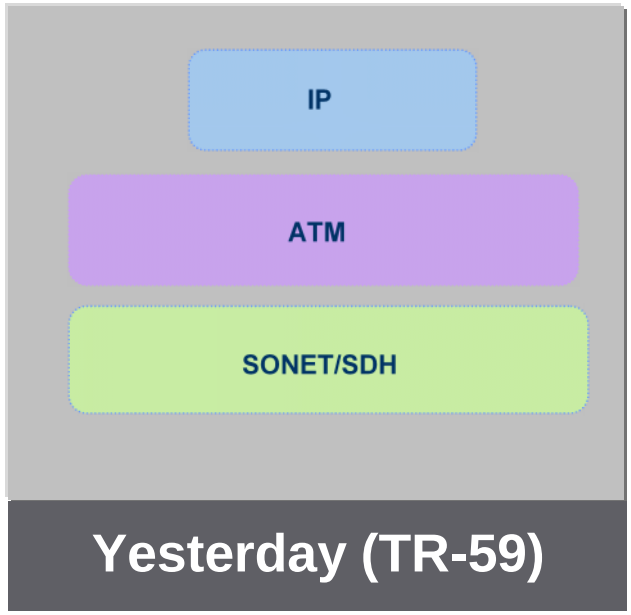
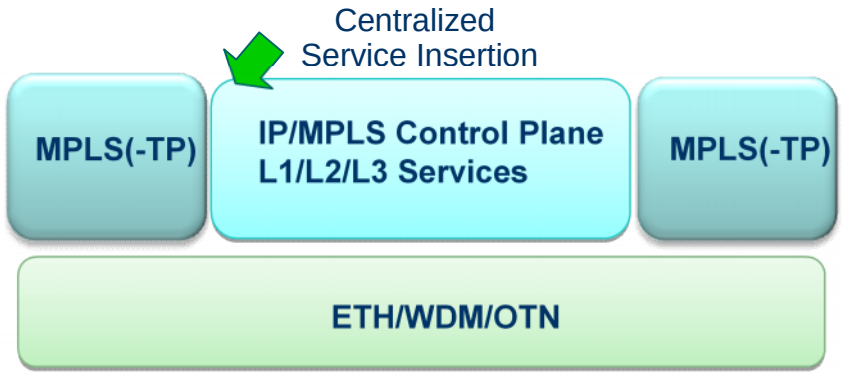
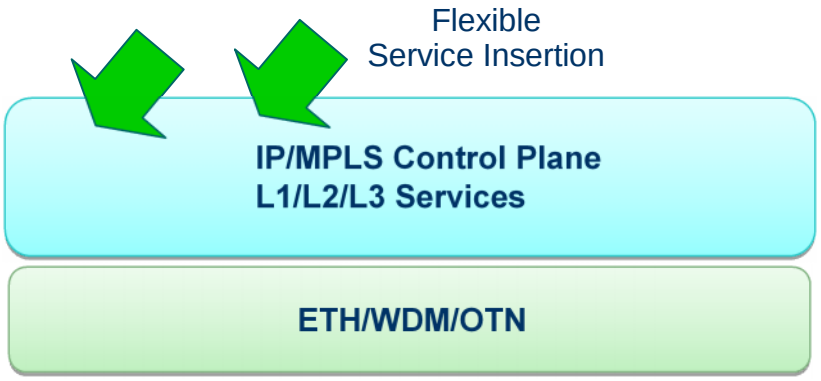
WT-145/178 : current snapshot of IP Service Edge Placement Evolution





- IP/MPLS control plane in core
- Fixed placement of Service Edges



- IP/MPLS dynamic control plane end to end
- Flexible placement of Service Edges

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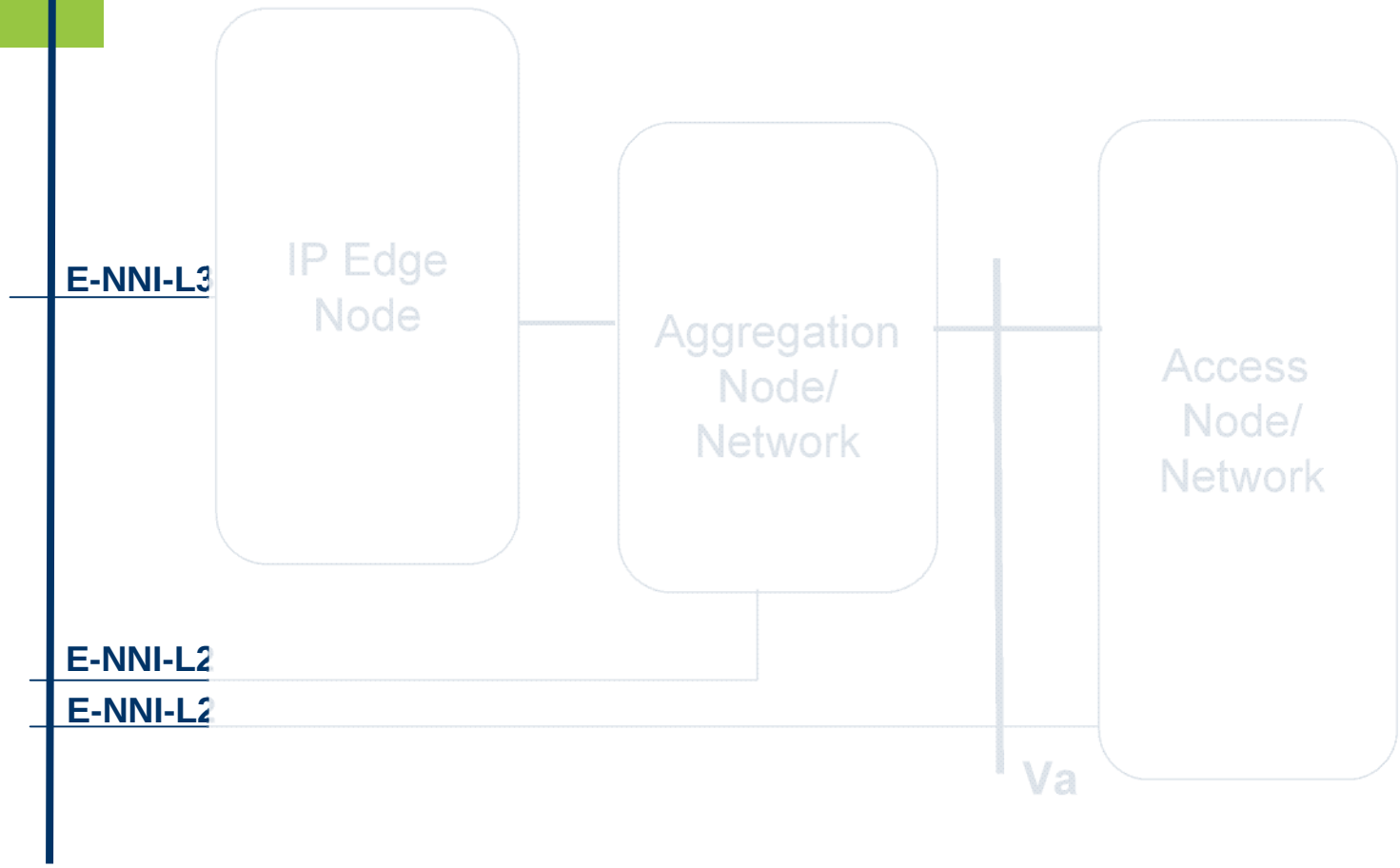
WT-178: Nodal Requirements for WT-145

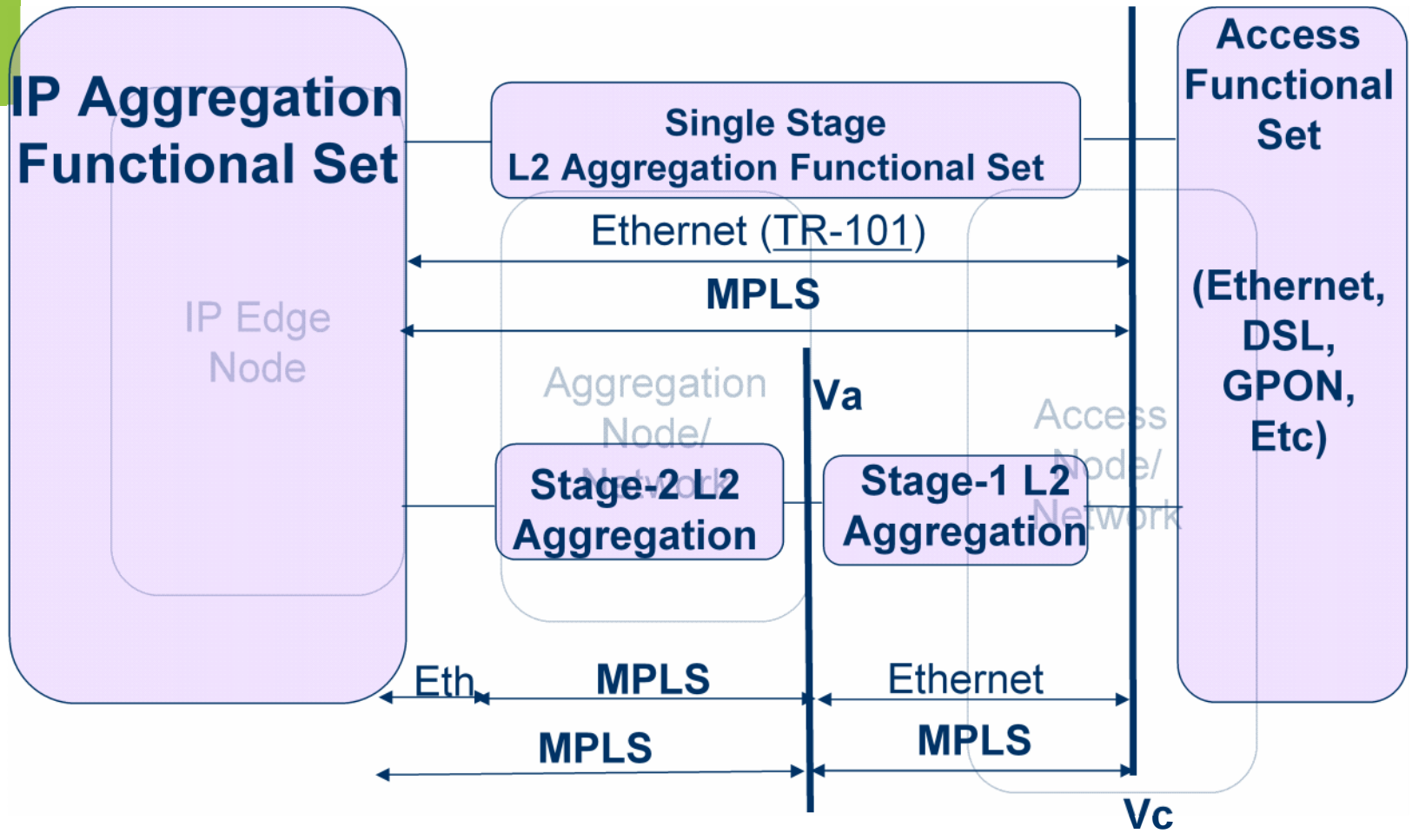


A10

T/U1

Note: WT-145/178 is work in progress

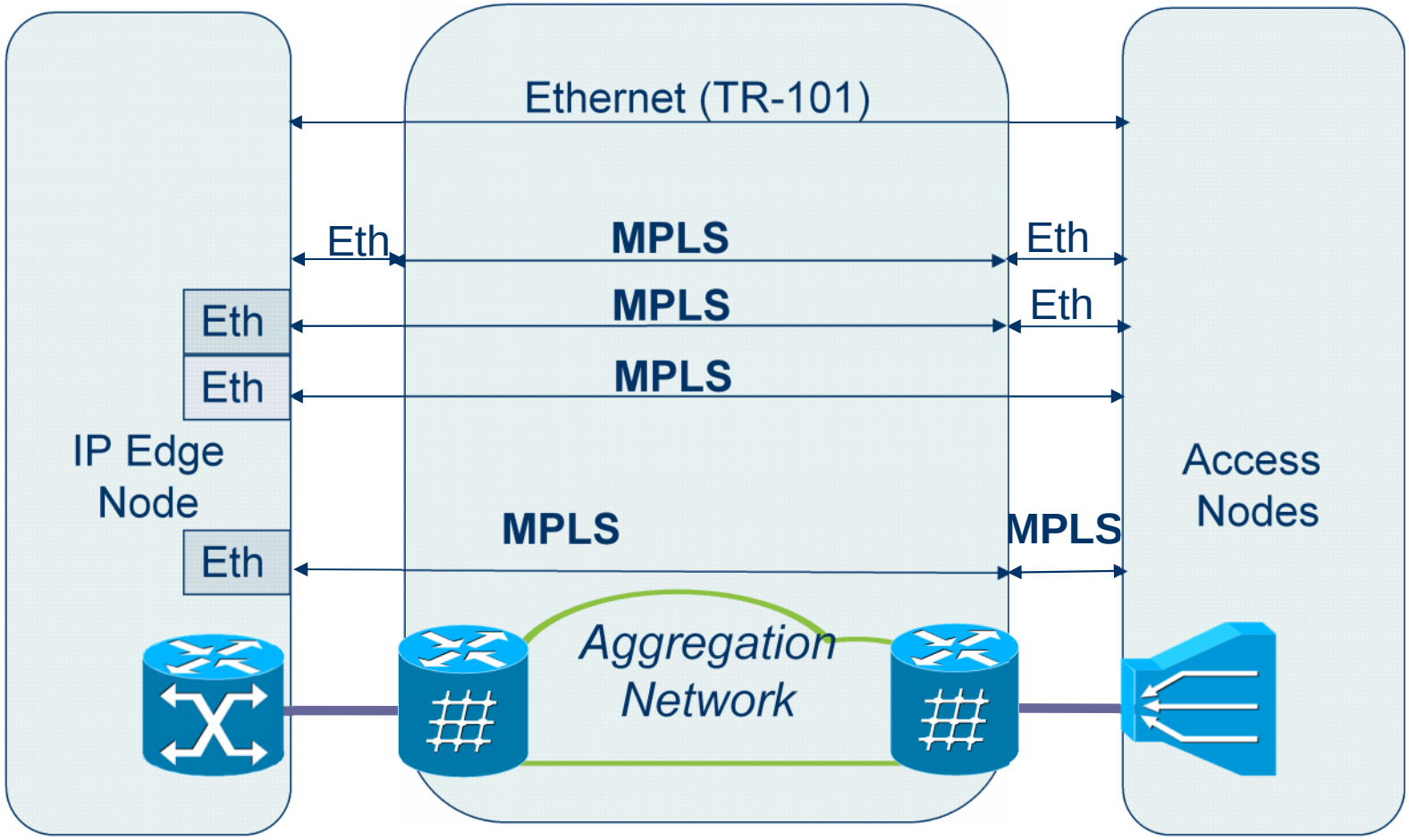
WT-178: Nodal Requirements for WT-145



Note 1: WT-145/178 is work in progress
Note 2: MPLS refers to any IETF functionality including the Transport Profile

MPLS(-TP) in WT-178 : Multiservice Broadband Nodal Requirements

Example topology and deployment models



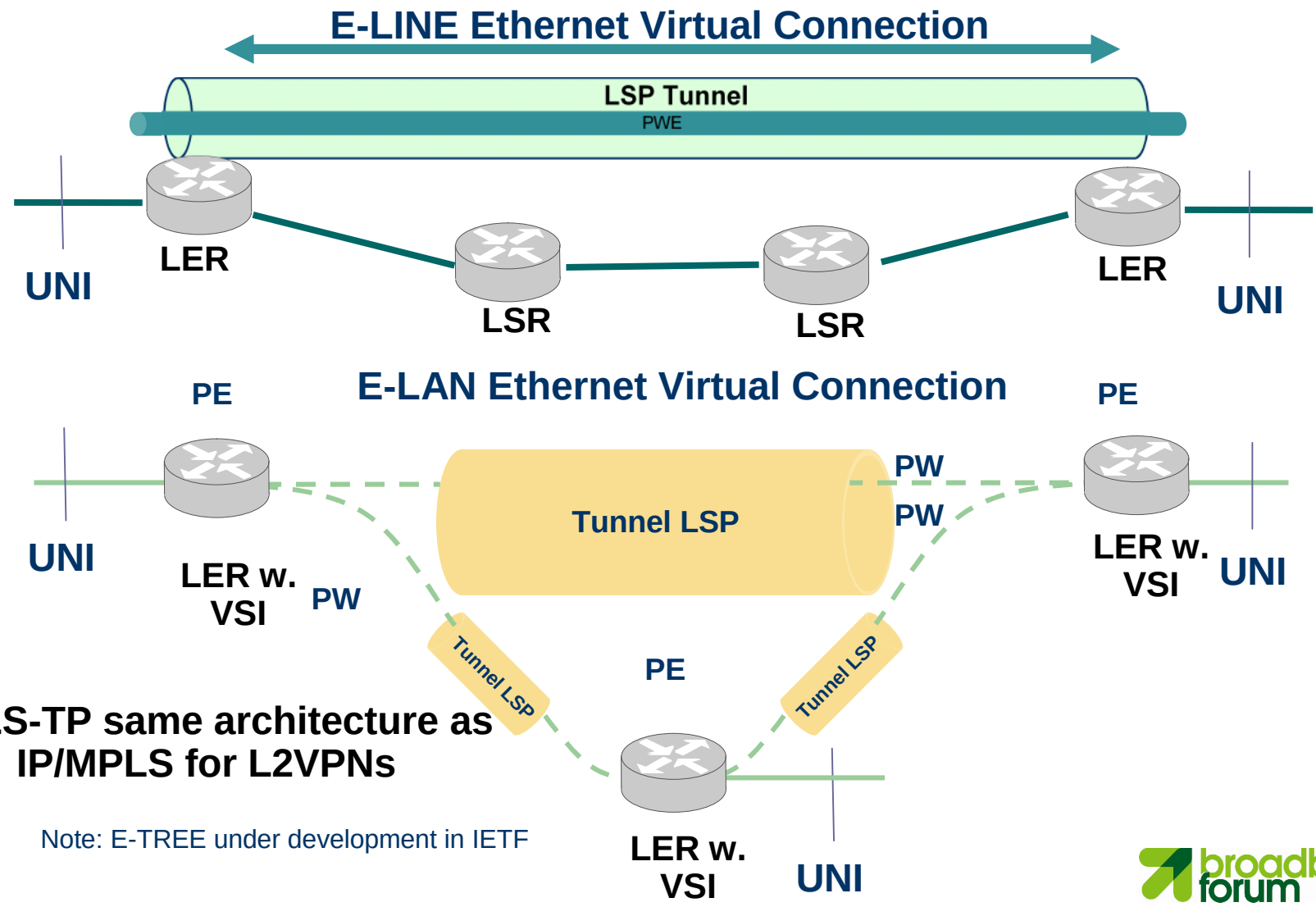
Note 1: WT-178 is work in progress
Note 2: MPLS refers to any IETF functionality including the Transport Profile

Applicability in Broadband Forum Architectures

Ethernet L2VPN Services

Ethernet Wholesale

Carrier Ethernet L2VPNs w. MPLS-TP



MPLS-TP same architecture as IP/MPLS for L2VPNs

Note: E-TREE under development in IETF

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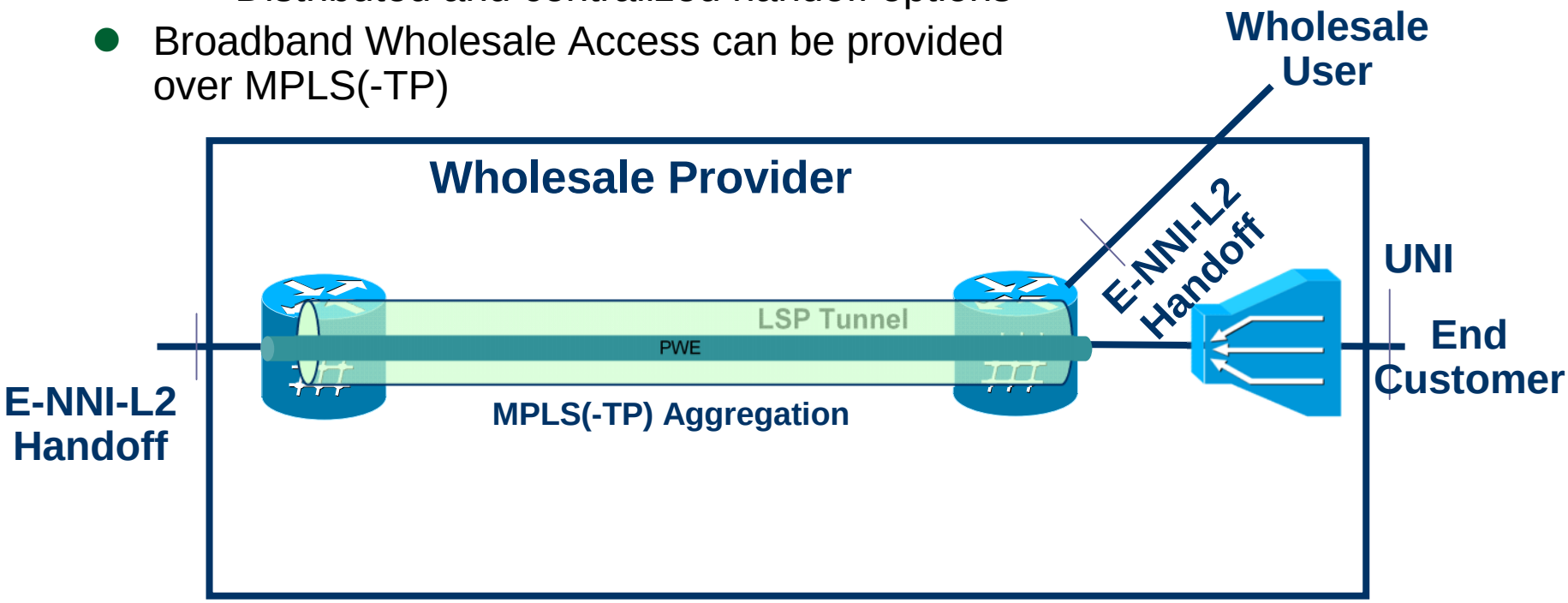
Broadband Wholesale Access

- Broadband Wholesale Access (*) :
  - Mix of E-LINE and E-TREE services
  - Distributed and centralized handoff options
- Broadband Wholesale Access can be provided over MPLS(-TP)



(*) See MD-229 , “Leveraging Standards for Next Generation Wholesale Access” Whitepaper

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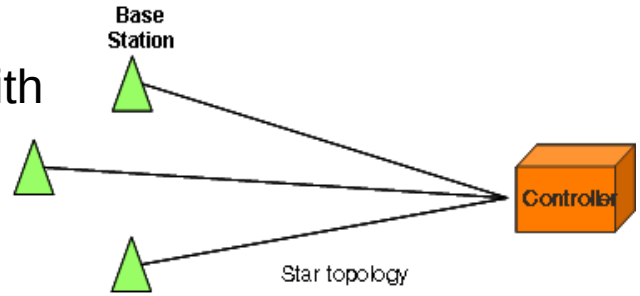
Applications in Broadband Forum Architectures

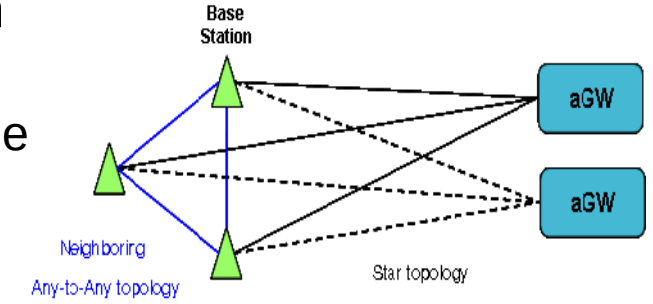
MPLS TP in Mobile Backhaul Networks

Mobile Backhaul Networks Topology

- 2G(GSM/CDMA) and 3G (UMTS/HSPA) Mobile Backhaul Networks are based on Centralized Connectivity Model:
  - Each Base Station communicates ***only*** with a single Radio Controller across a static path
  - The Network is designed in Hierarchical Aggregation Architecture (Centralized Architecture)



- LTE Backhaul Networks are based on an Any to Any Connectivity Model:
  - Each Base Station communicates with one or more Network Controllers (aGW)
  - Each Base Station communicates with its neighbouring Base Stations in order to forward user data traffic during handovers and to support signalling traffic.



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MPLS-TP Usage in 2G/3G Architecture

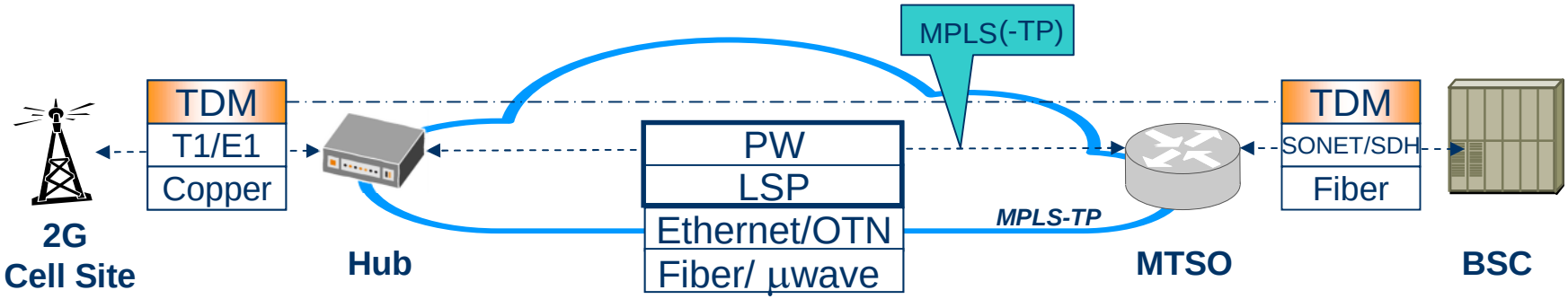
MPLS-TP can be used in 2G/3G Mobile Backhaul Networks :

- The centralized and static nature of the architecture can make use of the “Transport like” functionality
  - uses MPLS Pseudowires for Point-to-Point or Hub & Spoke connectivity
    - No need for Any to Any connectivity
  - bi-directional tunnels simplify the network provisioning process
- The TP specific features may be used to provide:
  - Advanced OAM and Protection to assure service survivability
  - Predictable delay and jitter

Backhaul of 2G/3G over Packet infrastructure

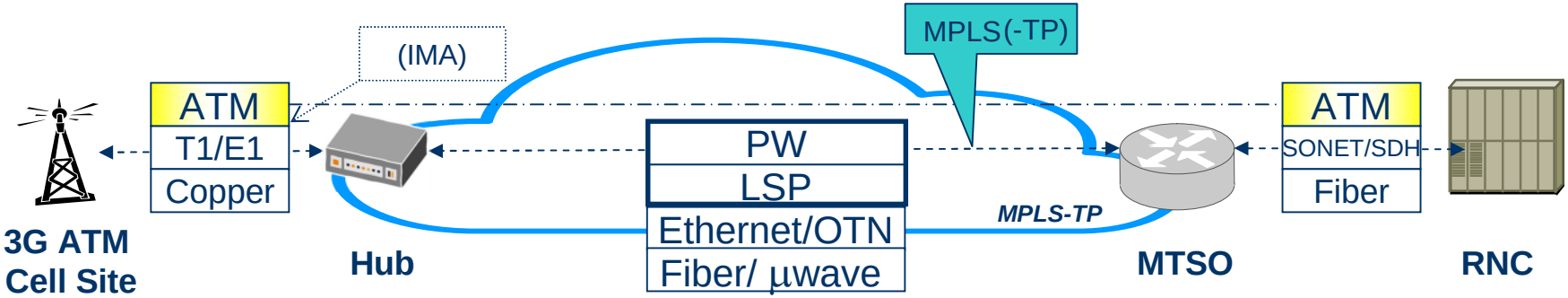
TDM

- RFC 4553 (structure agnostic)
- RFC 5086 (Circuit Emulation Services over Packet Switched Network)



ATM

- RFC 4717



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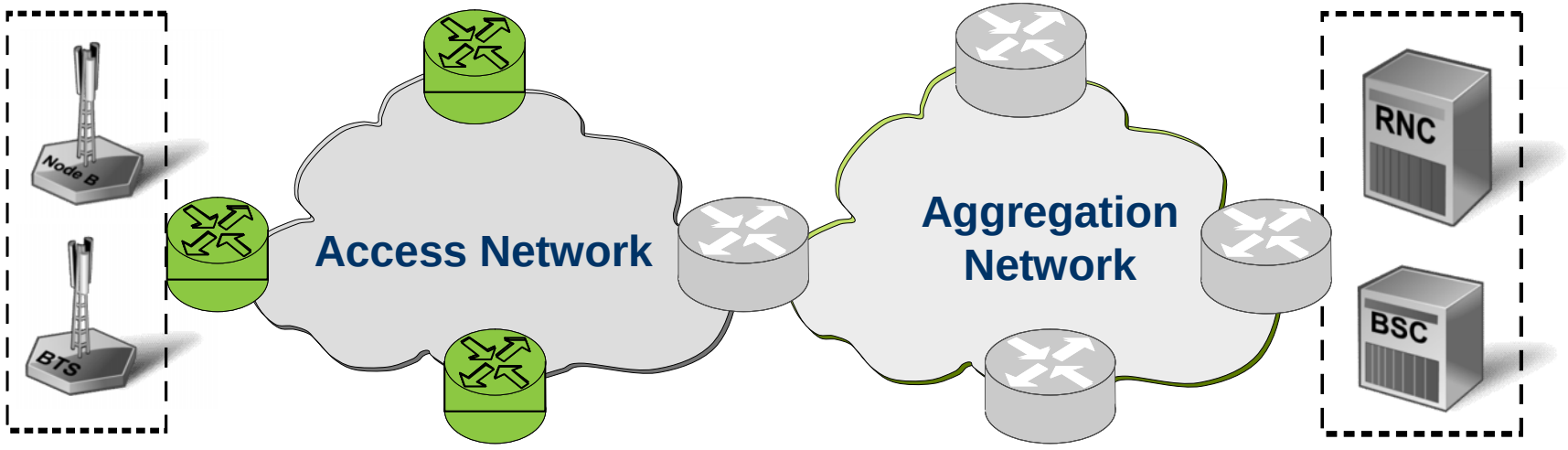
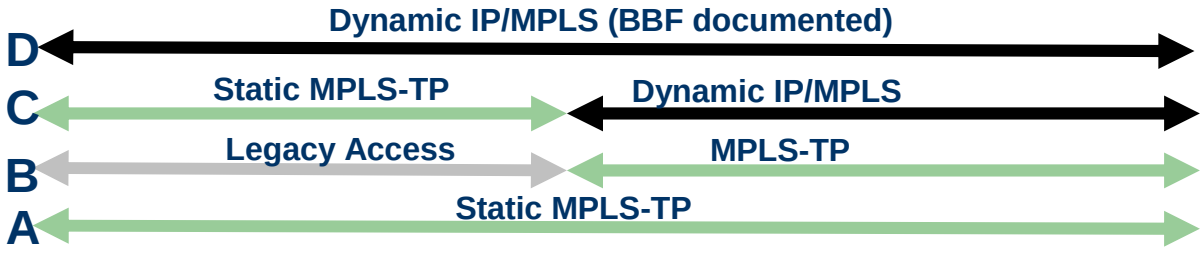
MPLS-TP in 2G/3G Backhaul Architecture

- MPLS-TP could be used in a 2G/3G backhaul network architecture in a similar manner to IP/MPLS:
  - A) across the entire Access & Aggregation network
  - B) inside Aggregation Network, Replacing the legacy Transport network
  - C) in the Access Network, Complementing IP/MPLS aggregation network
- See BBF MPLS in Mobile Backhaul Tutorial for information on how End to End IP/MPLS can be used (option D)





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MPLS-TP in LTE Networks

MPLS-TP can be used in LTE networks in a similar manner to IP/MPLS (*):

- When Any to Any connectivity can be feasibly supported with static provisioning
- MPLS-TP control-plane signaling (GMPLS) dynamically adds Any to Any connectivity when needed
- MPLS-TP advanced OAM, Restoration and Survivability mechanism can enhance monitoring and protection of the network/mission-critical service (e.g. Signaling)

* See MR-238, *MMBI White Paper on Use of MPLS in LTE*

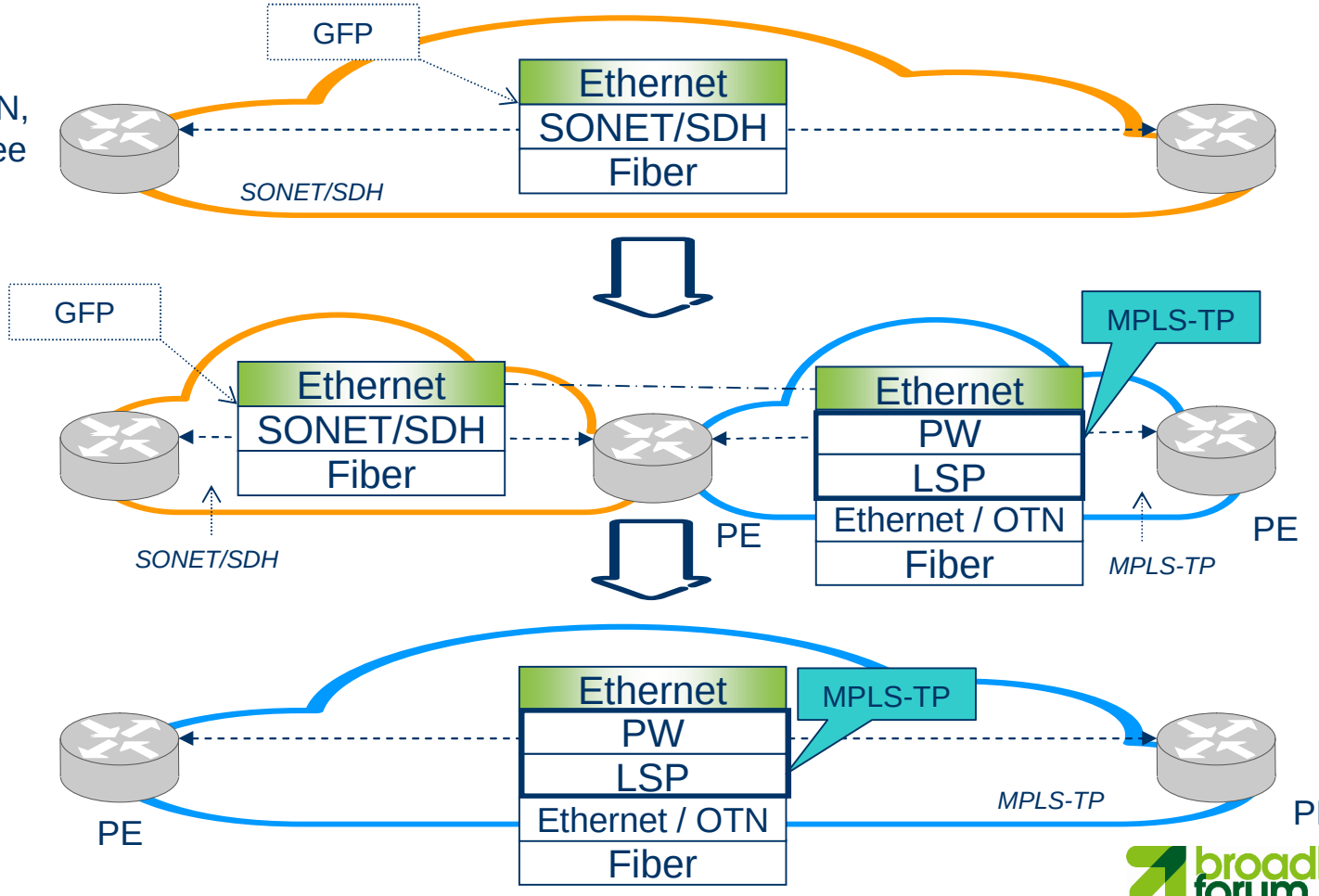
Network Scenarios

SONET/SDH to Packet interoperability

Example of Migration in Packet Optical Networks

Ethernet (SONET/SDH migration to Packet Transport Networks)

EPL, EVPL,
EPLAN, EVPLAN,
EPTree, EVPTree



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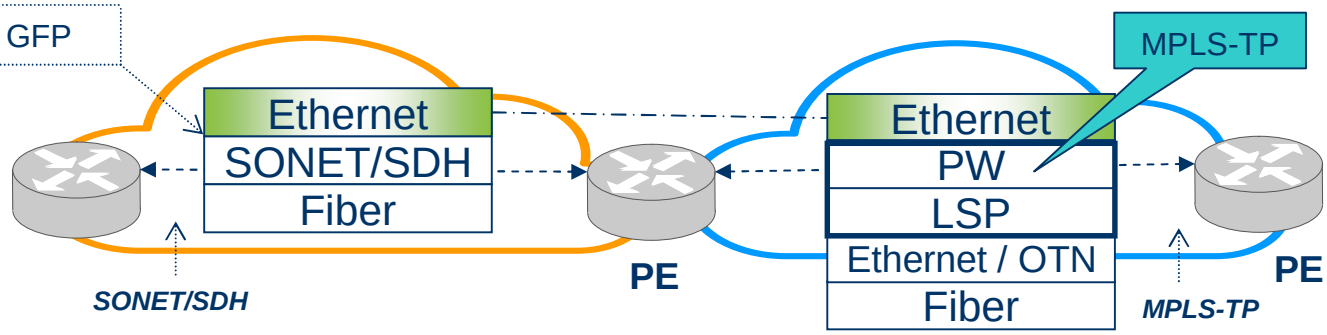
Example of SONET/SDH to MPLS-TP Interconnection

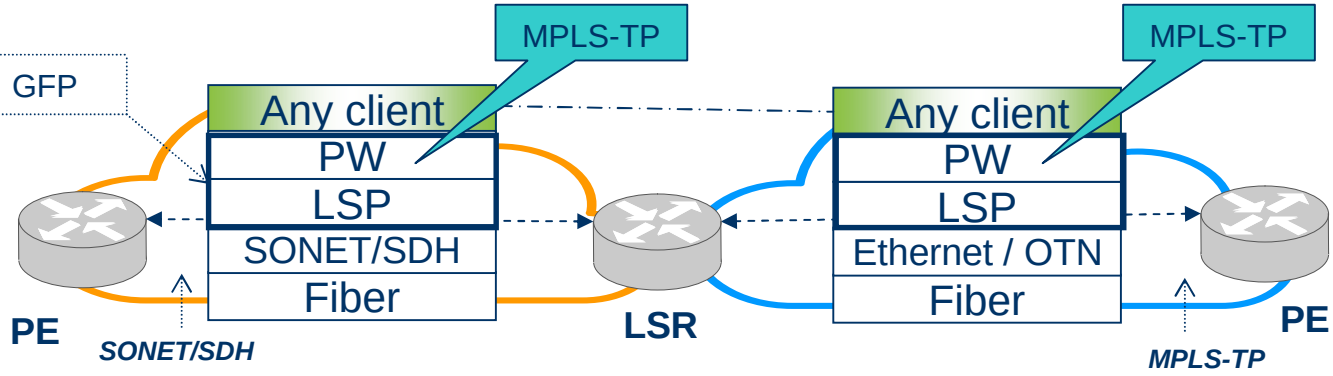
Ethernet interconnection

EPL, EVPL,
EPLAN, EVPLAN,
EPTree, EVPTree



MPLS-TP interconnection

Any client including
EPL, EVPL,
EPLAN, EVPLAN,
EPTree, EVPTree



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Summary

Summary

- ITU-T and IETF working together on MPLS-TP, with ITU-T providing Transport Requirements and IETF defining the protocols and functionality
- MPLS-TP leverages current MPLS functionality, as well as defines new functionality:
  - Standards definition focusing on OAM, protection, forwarding, control plane, and management
  - MPLS-TP is a subset of extended MPLS
  - New functionality can be leveraged in IP/MPLS networks
- The applicability of MPLS-TP to multi-service broadband architectures, as well as specifying interoperability requirements is under active study at the Broadband Forum

Related Standards Organizations and Consortiums

- **Broadband Forum:** http://www.broadband-forum.org
- **IETF:** http://www.ietf.org
- **ITU-T:** http://www.itu.int/itu-t

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Thank you for attending the MPLS-TP in Multi-Service Packet Network Deployments Tutorial

For more information, visit us at

http://www.broadband-forum.org

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Abbreviations

ATM - Asynchronous Transfer Mode
BBF – Broadband Forum
BFD – Bidirectional Forwarding Detection
CC – Continuity Check
CDMA – Code Division Multiple Access
CV – Continuity Verification
DCC – Data Communications Channel
DM – Delay Management
DWDM – Dense Wave Division Multiplexing
ECMP – Equal Cost Multipath
E-NNI – External Network to Network Interface
ETH – Ethernet
FR – Frame Relay
FRR – Fast ReRoute
GACh – Generic Associated CHannel
GAL – Generic Alert Label
GMPLS – Generic MPLS
GSM – Global System for Mobile Communications
HSPA – High Speed Packet Access
IETF – Internet Engineering Task Force
IP/MPLS – Internet Protocol / Multi Protocol Label Switching
ITU – International Telecommnuication Union
LDP – Label Distribution Protocol
LER – Label Edge Router
LM – Loss Management

Abbreviations (2)

LMP – Link Management Protocol
LSP – Label Switched Path
LSR – Label Switch Router
MC-APS – Multi Chassis – Automatic Protection Switching
MCC – Management Communication Channel
MC-LAG – Multi Chassis – Link AGgregation
MPLS – Multiprotocol Label Switching
MPLS-TP – MPLS Transport Profile
MSPW – Multi Segment Pseudowire
NGN – Next Generation Network
NMS – Network Management System
OAM – Operations and Management
OSPF-TE – Open Shortest Path First – Traffic Engineering
OTN – Optical Transport Networking
P – Provider (Node)
P2MP – Point to Multipoint
P2P – Point to point
PDH - Plesiochronous Digital Hierarchy
PE – Provider Edge (Node)
PHP – Penultimate Hop Popping
POS – Packet over SONET
PPP – Point to Point Protocol
PSTN – Public Switched Telephony Network
PW - Pseudowire
PWE3 – Pseudowire Emulation End to End

Abbreviations (3)

QoS – Quality of Service
RDI – Remote Defect Indicator
RFC – Request For Comments
RSVP-TE – Reservation Protocol – Traffic Engineering
SCC – Signalling Communication Channel
SDH – Synchronous Digital Hierarchy
SLA – Service Level Agreement
SONET - Synchronous Optical NETworking
S-PE – Switching PE
SPME – Sub-Path Maintenance Entity
SSPW – Single Segment Pseudowire
TC – Tandem Connection
TDM – Time Division Multiplexing
T-LDP – Targeted Label Distribution Protocol
TLV – Type ,Length, Value
T-PE – Terminating PE
TR – Technical Report
UMTS – Universal Mobile Telecommunication System
UNI – User to Network Interface
VPN – Virtual Private Network
VSI – Virtual Switching Instance
WDM – Wave Division Multiplexing
WT – Working Text

The Broadband Forum

Thank You