Deconstructing Next Generation Transport: An Industry, Technology and Services Overview

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October 9 2007

MPLS JAPAN
Hosted by e-side

Agenda

- Industry Dynamics
- Ethernet Trends and Convergence
- Standards Overview
- Service Mapping
- Summary

Industry Dynamics

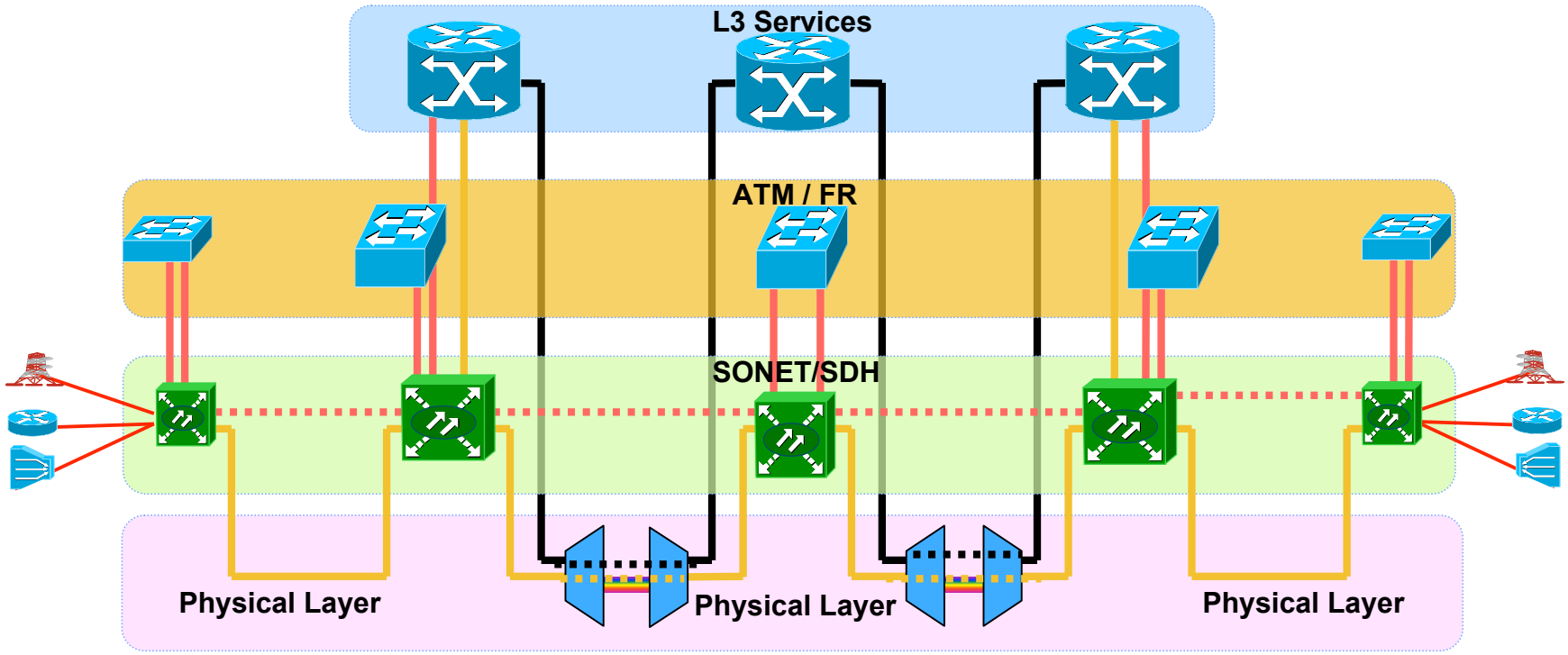
Market Trends and Focus

- Ethernet at access for service aggregation
- Require service flexible architecture
- Capex and Opex efficient
- OAM and Network management key
- High availability and resiliency
- “Adaptation” of packet switching technologies to the transport domain
- Utilization of legacy strategy where ATM technology was used both as a “transmission” and a “switching” technology
- Migration to IP/MPLS and Ethernet based core switching
- Elimination of unneeded control plane capabilities and functionalities in transmission applications
- Multiple overlay and supplemental proposals and techniques, including T-MPLS,PBB-TE, to adapt IP/MPLS and Ethernet to the transport arena

Packet Transport Market Dynamics

- Traditional circuit switched transport systems are migrating toward packet based technologies
- SDH/SONET platforms provide low speed bandwidth granularity network services and high speed long haul transmission services
- IP adoption and convergence simplifies packet transport networks in the access/aggregation and metro domains to reduce CapEx and OpEx in next generation networks

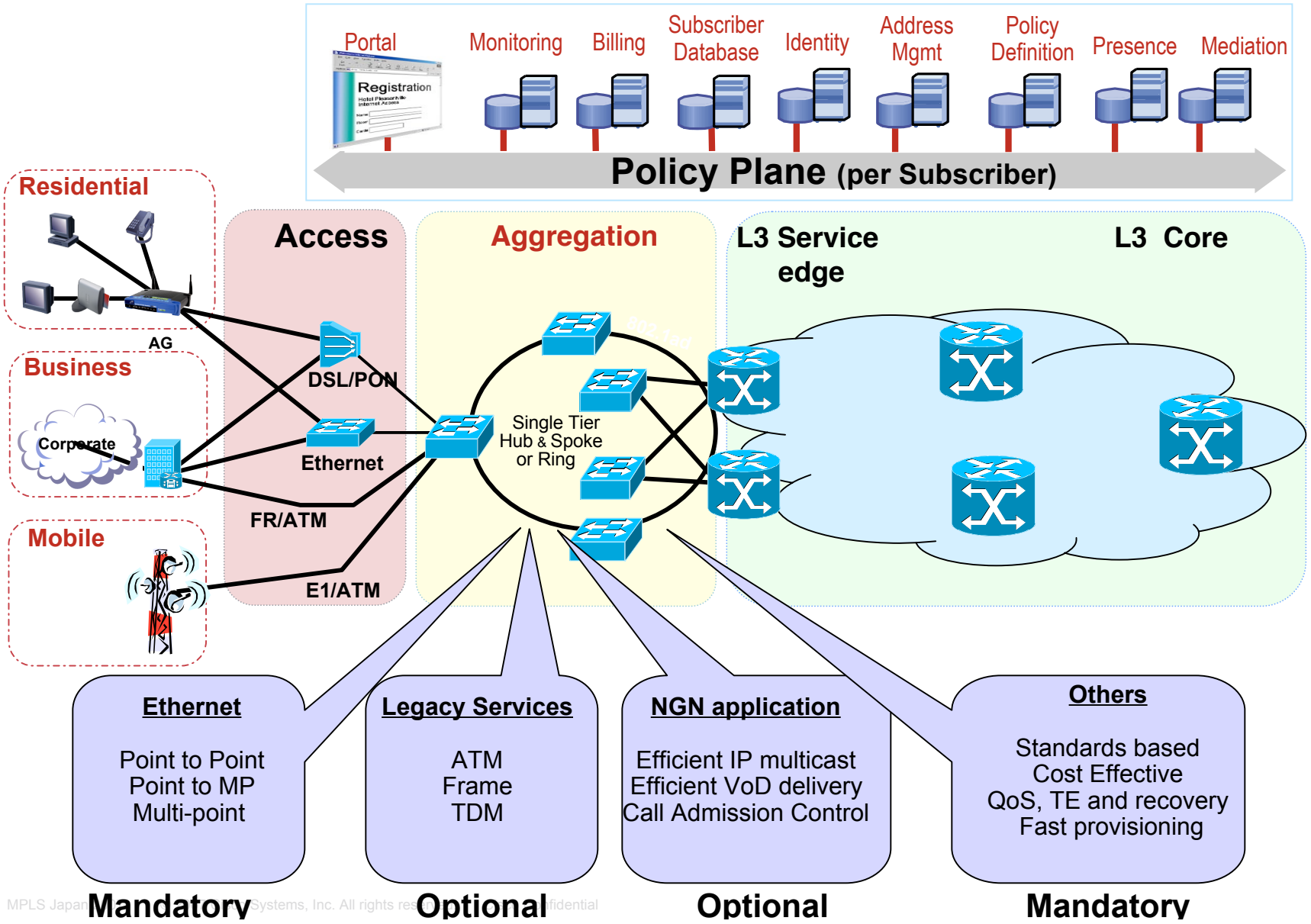
Where we are today !!



Characteristics and issues

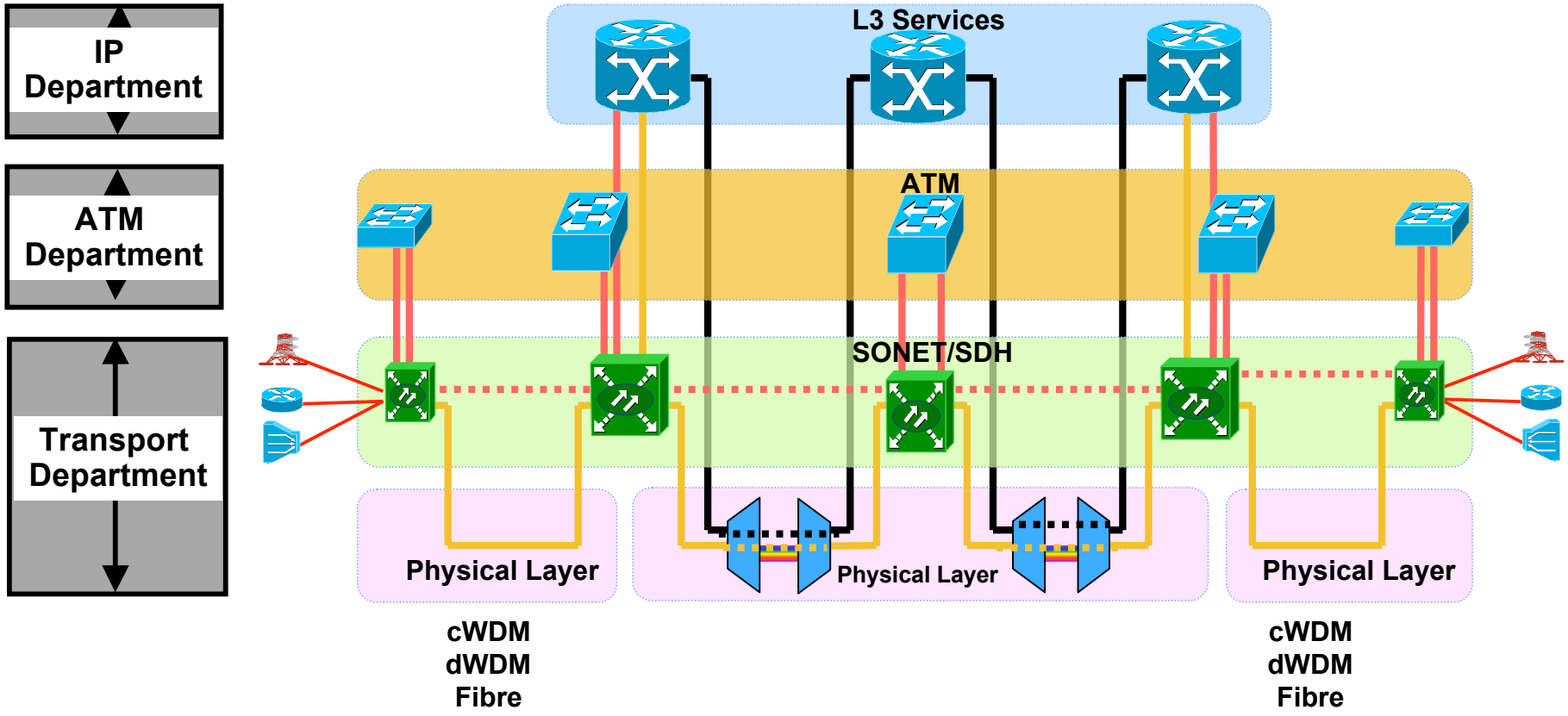
- Network centric
  - Circuit orientated
- Multiple networks
  - OPEX and CAPEX inefficiencies
  - Provisioning and service assurance complexities
  - Complexity between layers
- ATM and F/R technology is tailing off
  - Service capabilities
  - Bandwidth concerns
- NG SDH/SONET days numbered
  - TDM and circuits not well suited for packet transport
  - Acknowledged by transport vendors and SPs
  - Discussion is now about high performance packet networks
- Service capability may still be required
  - Regulation
  - Evolution may not be possible

Next Generation Transport Requirements



Ethernet Transport And Convergence

Existing roles and responsibilities



- Organisational lines drawn based on networks
- Cross charging between groups
  - Transport to ATM, Transport to IP, ATM to IP
  - Creates considerable friction
  - Can cause organisational breakdowns (IP department buys dark fibre, dwdm gear)

Characteristics

- Multiple networks
  - Different services, different capabilities
- Complex interaction between layers
- Layer 3 components tend to be fairly centralised in nature
- Most SPs believe the number of networks has to be rationalized
- New services are demanding more bandwidth
  - Existing transport and ATM networks will not scale
  - All see the need to build a high speed packet transport networks

Service Requirements

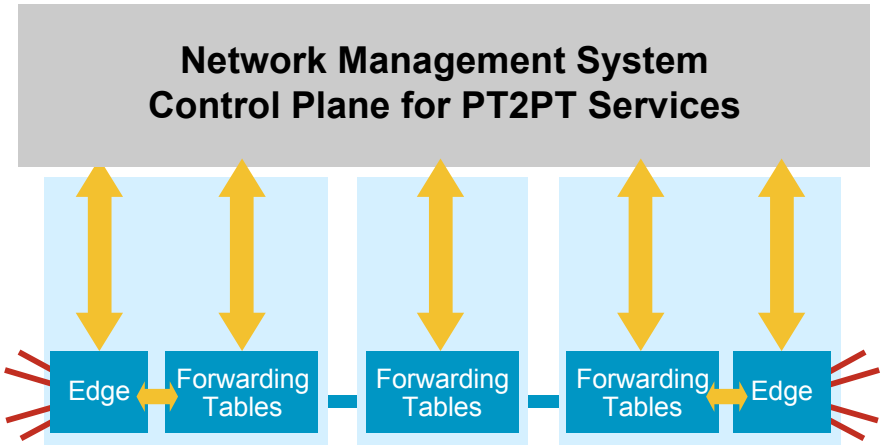
Consumer	Business	Wholesale	Evolved services
Internet Voice / Video / data Voice PSTN / Multimedia Video Over the Top Walled Garden Mobility	TDM/ATM→Ethernet L2 VPNs Pt2Pt Pt2MPt MPt2MPt L3 VPNs Connectionless Value-add Services Based on L3 visibility	TDM/ATM→ Ethernet L2 VPNs Pt2Pt Pt2MPt MPt2MPt L3 VPNs L2TP Connectionless	PSTN Migrate Mobile RAN backhaul IP transition TDM Migrate and evolve to Ethernet ATM Migrate and evolve to Ethernet F/R Evolve to Ethernet

Moving forward

- **Service Oriented Architecture**
  - Functionality placed where it makes sense for optimal service delivery
  - Infrastructure and demographics
  - Traffic flows
- **IP is the service protocol**
  - Not Ethernet, Not optical, Not MPLS
  - Other than dumbest optical transport all NGN networks need IP disciplines
  - So do the organisations running them
- **Network convergence**
  - CAPEX and OPEX reduction
  - Ease of provisioning and service assurance

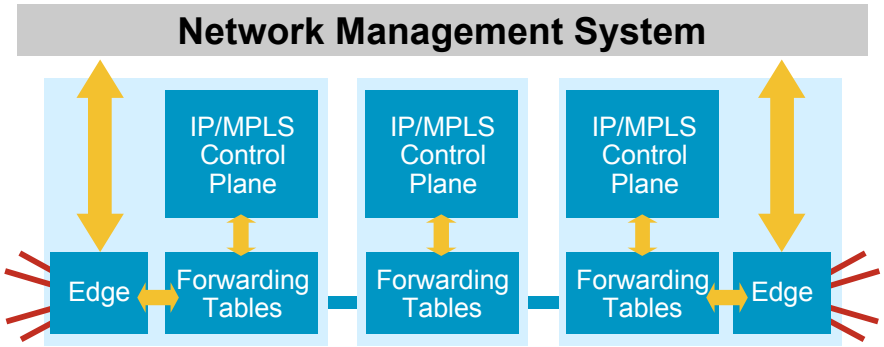
Control Plane Comparison

Provider Backbone Transport and T-MPLS



- NMS based Control Plane
- Long term support integrated control plane?
  - PBT and T-MPLS → G-MPLS
  - G-MPLS – Link state Protocol, RSVP etc
- Single Service Control Plane
  - Pt2Pt Only

IP/MPLS



- Integrated Control Plane
- Multi-service Control Plane
  - L1, L2, L3
  - Pt2Pt, Multipoint

PBT / T-MPLS : Simply moves complexity to the Network Management layer

Packet Transport forwarding and control plane

- **IP/MPLS (EoMPLS and VPLS):-**
  - Lot of initial success: - but mainly sold as next generation ATM
  - Based on the encapsulation customer traffic in two or more labels
  - Label forwarding within the core based on provider label
  - IP/MPLS control plane

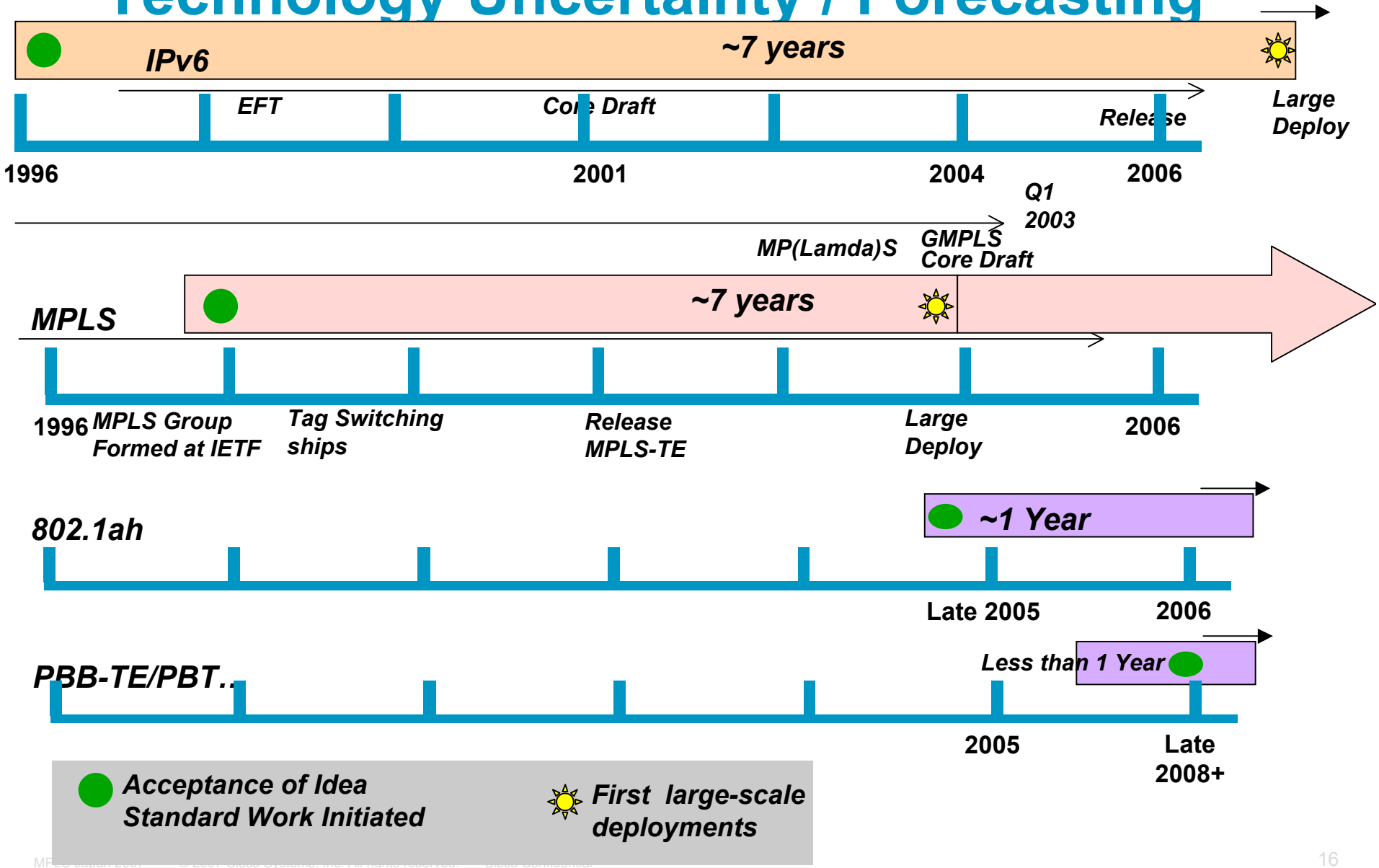
- **Provider Backbone Bridge-Traffic Engineering :-**
  - Emerging Ethernet solution
  - Based on encapsulation of customer traffic in backbone mac address
  - Ethernet forwarding within the core based on provider backbone mac address
  - NMS based control plane (discussing the use of G-MPLS)

- **PBT:-**
  - Vendor proprietary

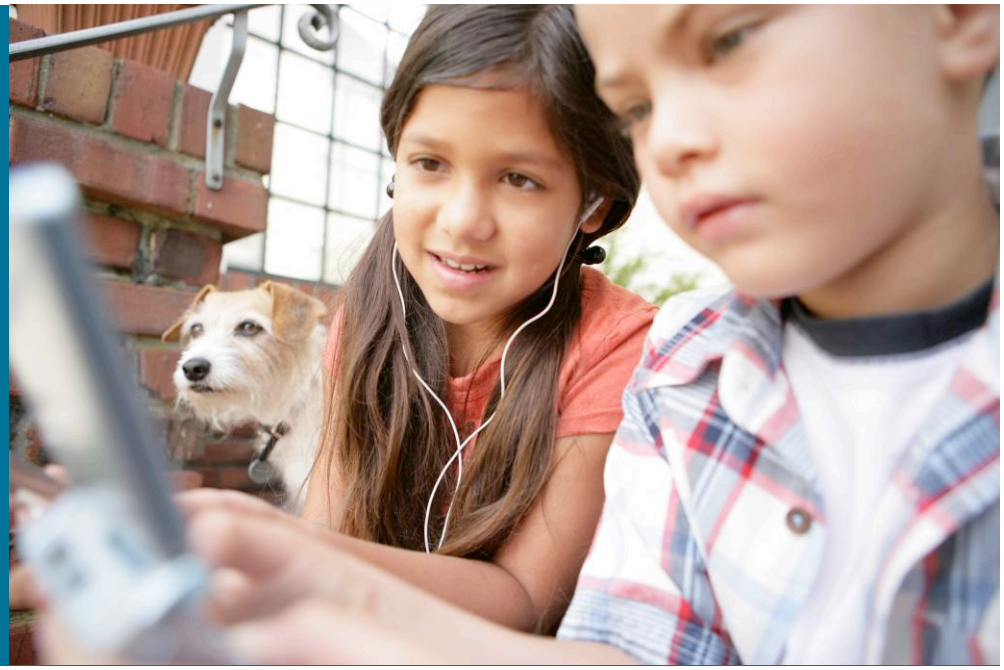
- **T-MPLS :-**
  - Emerging
  - Based on the encapsulation customer traffic in two or more labels
  - Label forwarding within the core based on provider label
  - NMS based control plane (discussing the use of G-MPLS)

- **Arguments over which option**
  - CAPEX cost :- Ethernet and transport solutions are cheaper than IP solutions
  - Complexity of IP control plane :- OPEX associated with operating the solution

Technology Uncertainty / Forecasting



Standards Overview



T-MPLS and IETF MPLS

- **T-MPLS supporter's claim it is a subset of IETF MPLS**
  - Pseudo-wire concept, same Ethertype
  - T-MPLS simplifications are covered by the IETF MPLS RFCs

- **Inter-operability will be challenging**
  - Different OAM mechanisms
  - Different signaling protocols for pseudo-wires
  - Different control planes using same Ethertype (label management)

- **SG 15 Q.12 September 2007**

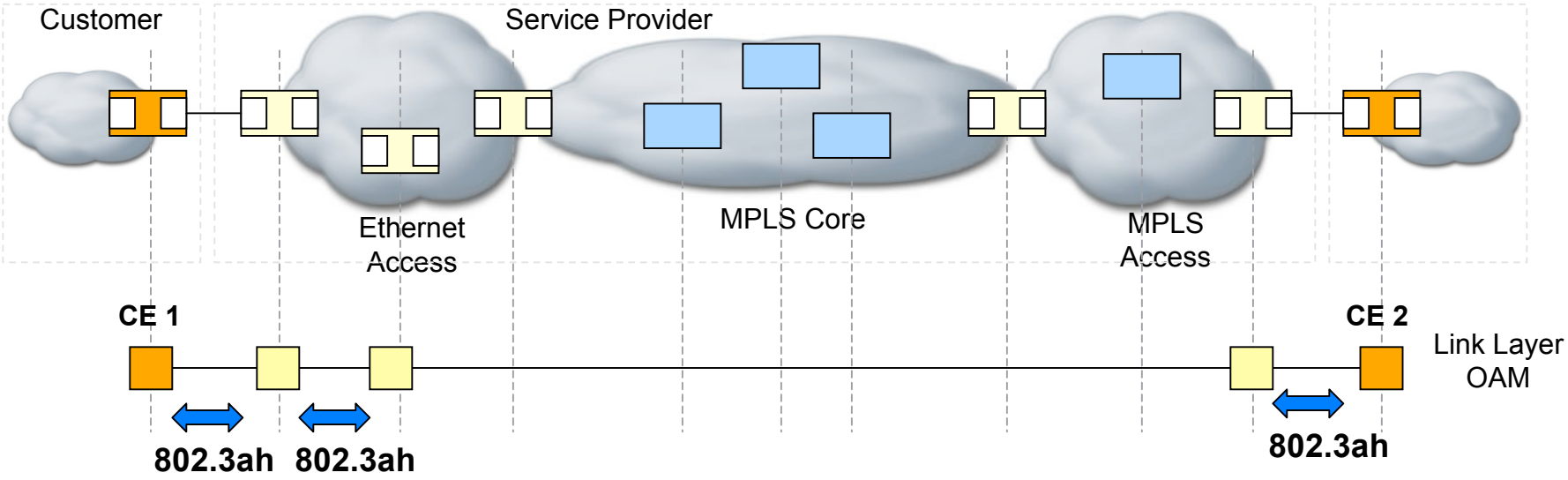
Agreement to use IETF Standards Process for T-MPLS future work and to examine the existing ITU-T Recommendations by IETF to resolve any issues (inconsistencies, incompatibilities or omissions) with the use of IETF MPLS by amending already approved (or consented) ITU-T Recommendations.

- draft-ietf-pwe3-mpls-transport-01

IEEE 802.1Qay Provider Backbone Bridges Traffic Engineering

- New work item to define traffic engineering extensions for 802.1ah
- IEEE 802.1 Project Authorization Request (PAR) approved in November 2006
- Standardization expected to take at least 2-3 years
- Motivated by provider backbone transport (PBT) discussion
- How similar/different PBB-TE and PBT will look is unknown

802.3ah



- Link Level OAM
- Operates on point-to-point link, not propagated beyond a single hop.
- Slow Protocol (Max rate of 10 frames per second)
- Functions:

  OAM discovery – Discover OAM capabilities on peer device

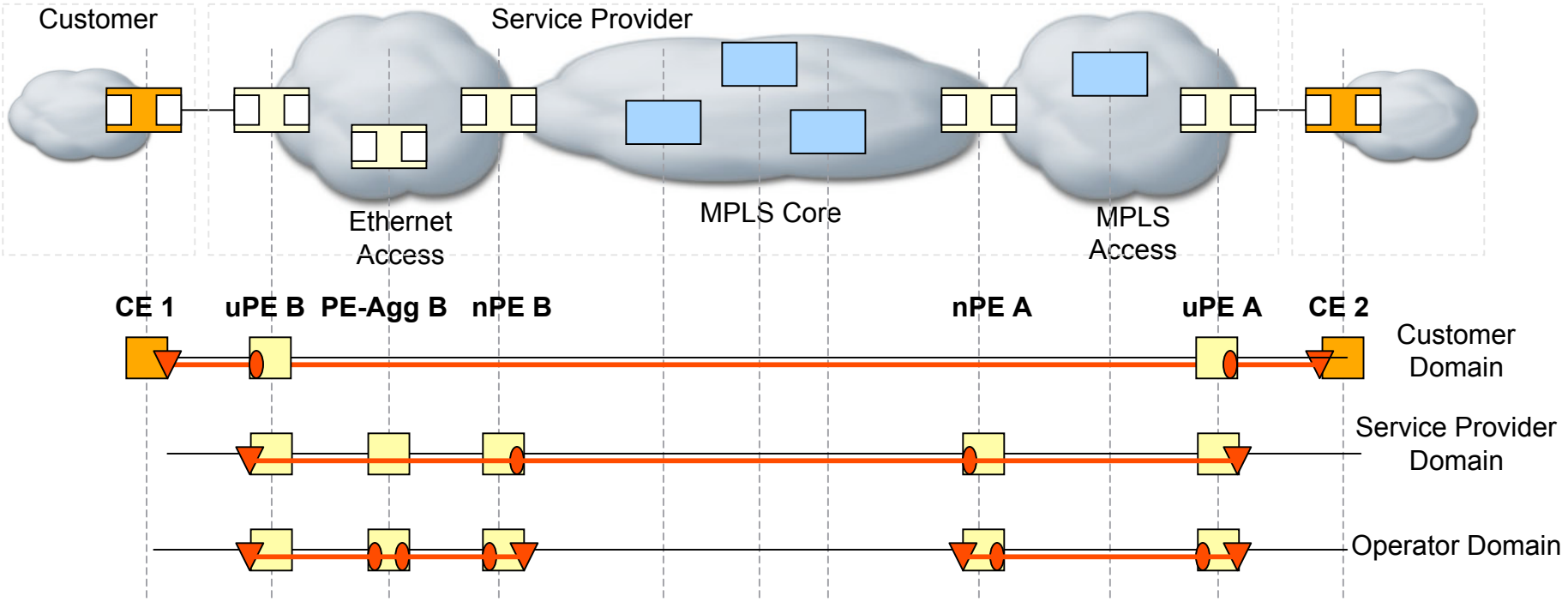
  Link monitoring – Event notification when error thresholds exceeded

  Remote MIB Variable Retrieval – Polling and response (but not writing) of 802.3ah MIB

  Remote Failure indication – Inform peer that receive path is down.

  Remote Loopback – Puts peer in (near-end) intrusive loopback state. Statistics can be collected while testing link.

802.1ag Connectivity Fault Management (CFM)

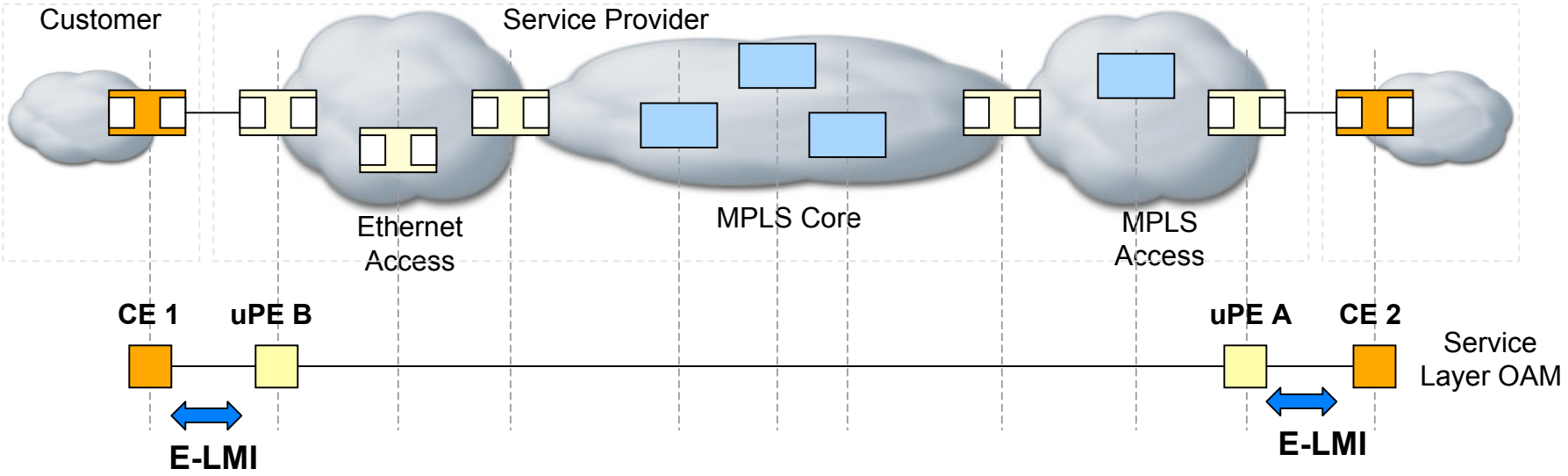


- End to End per EVC OAM
- Hierarchical Maintenance Domains
  - MEPs/MIPs
- Standard Ethernet Frames (in-band)
  - Continuity Check
  - Loopback
  - Link Trace

Y.1731

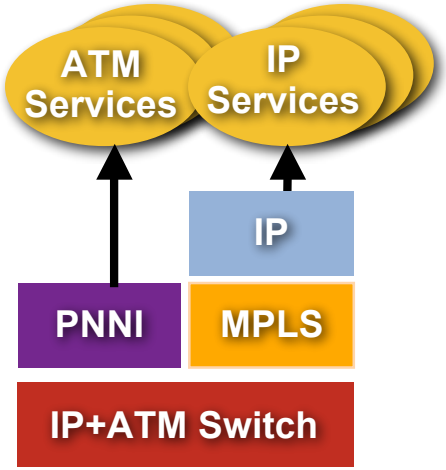
- CFM plus…
  - ETH-LCK (out of service diagnostics)
  - Multicast Loopback
  - AIS
  - TEST
  - Maintenance Communication Channel
  - Experimental OAM
  - Performance Management (Delay, Packet loss, Jitter)

E-LMI

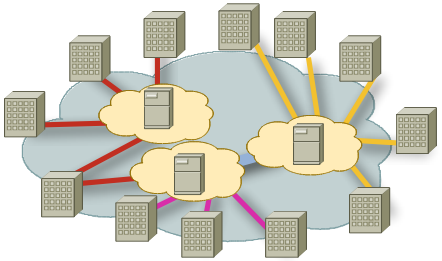


- Asymmetric protocol, applicable on UNI only (uPE to CE)
- Specifies procedures & message formats exchanged and NOT how uPE collects OAM data – relies on Service/Network OAM running uPE to uPE
- Allows uPE to communicate to CE:
  - EVC Status
  - Remote UNI Status
  - CE-VLAN to EVC Map
  - BW Profiles

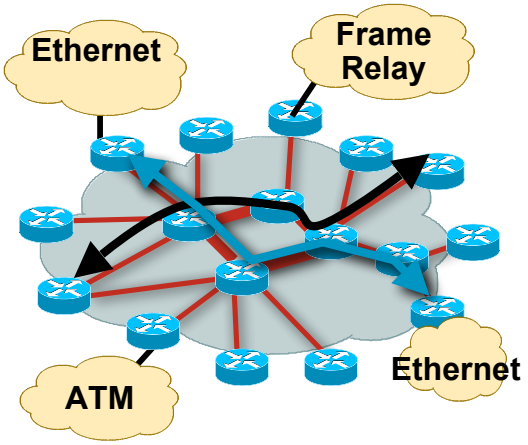
MPLS Evolution



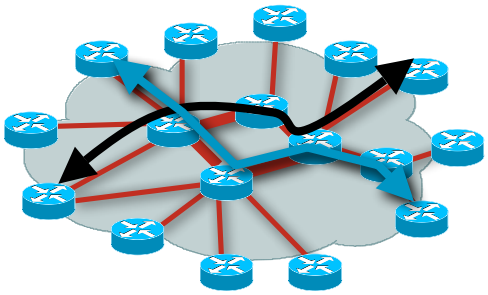
IP + ATM Integration



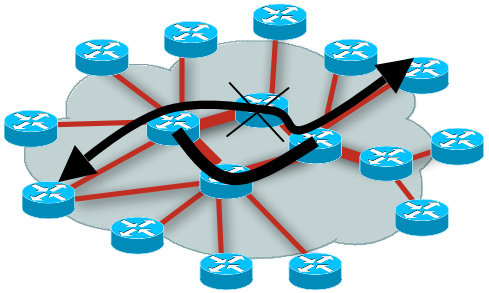
MPLS VPNs: Scalable Network based VPNs



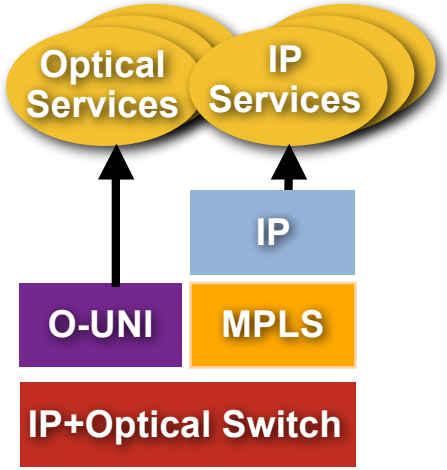
Layer 2 Integration for a converged network



Traffic Engineering: Bandwidth Optimization of traffic

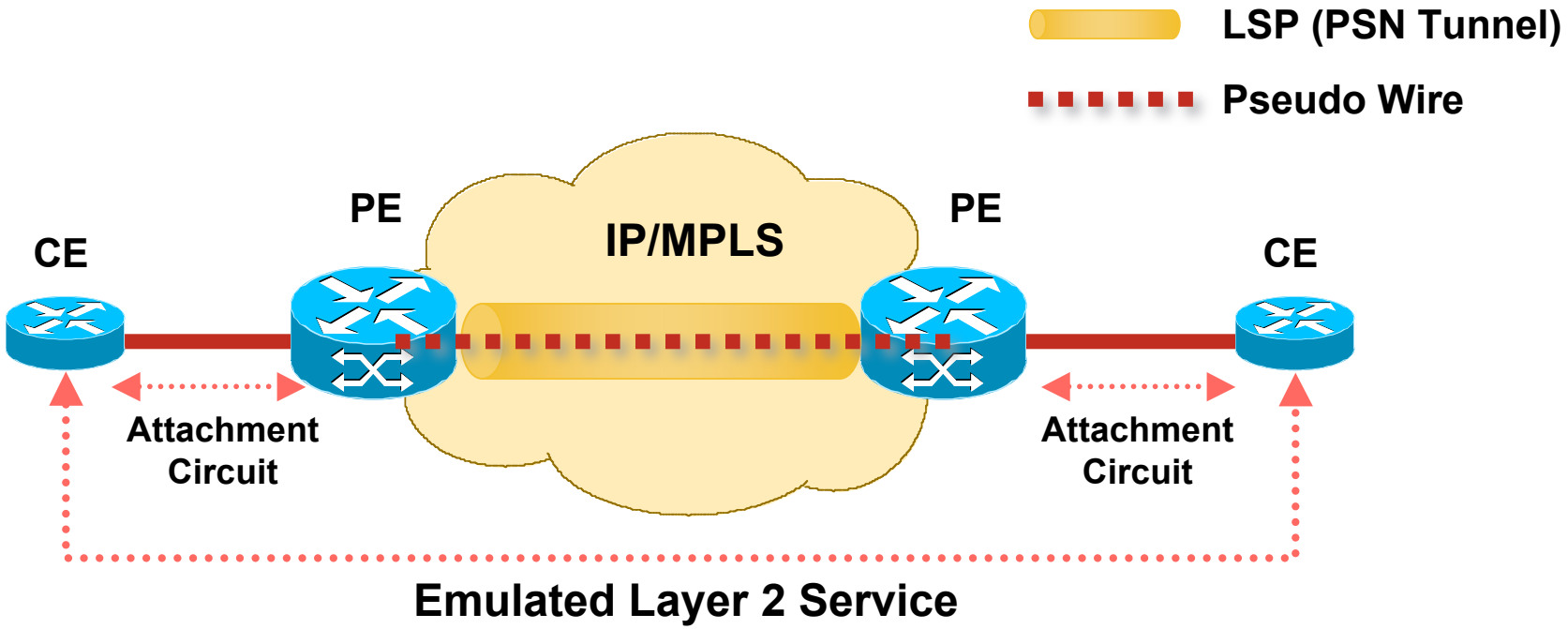


Bandwidth Protection and Resiliency



IP+Optical Integration

Pseudo Wire Reference Model



- A pseudowire (PW) connects native Layer 2 attachment circuits
- Establishment of PWs is signaled between PEs using LDP
- LSP ultimately carries PW traffic between PEs

Recent IP/MPLS Standards Published by IETF In last 12-14 Months, Few of them..

RFC 4364	BGP/MPLS IP Virtual Private Networks (PS)	Feb-06
RFC 4665	Service Requirements for Layer 2 Provider Provisioned Virtual Private Networks	Sep-06
RFC 4664	Framework for Layer 2 Virtual Private Networks (L2VPNs)	Sep-06
RFC 4684	Constrained Route Distribution for Border Gateway Protocol/Multiprotocol Label Switching (BGP/MPLS) Internet Protocol (IP) Virtual Private Networks (VPNs)	Nov-06
RFC 4659	BGP-MPLS IP Virtual Private Network (VPN) Extension for IPv6 VPN	Sep-06
RFC 4577	OSPF as the Provider/Customer Edge Protocol for BGP/MPLS IP Virtual Private Networks (VPNs)	Jun-06
RFC 4447	Pseudowire Setup and Maintenance using the Label Distribution Protocol (LDP)	Apr-06
RFC 4385	Pseudowire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN	Feb-06
RFC 4197	Requirements for Edge-to-Edge Emulation of Time Division Multiplexed (TDM) Circuits over Packet Switching Networks	Oct-05
RFC 4448	Encapsulation Methods for Transport of Ethernet Over MPLS Networks	Apr-06
RFC 4553	Structure-Agnostic Time Division Multiplexing (TDM) over Packet (SAToP)	Jun-06
RFC 4623	Pseudowire Emulation Edge-to-Edge (PWE3) Fragmentation and Reassembly	Apr-06
RFC 4619	Encapsulation Methods for Transport of Frame Relay Over MPLS Networks	Sep-06
RFC 4618	Encapsulation Methods for Transport of PPP/High-Level Data Link Control (HDLC) over MPLS Networks	Sep-06
RFC 4717	Encapsulation Methods for Transport of Asynchronous Transfer Mode (ATM) over MPLS Networks	Dec-06
RFC 4655	A Path Computation Element (PCE) Based Architecture	Aug-06
RFC 4657	Path Computation Element (PCE) Communication Protocol Generic Requirements	Sep-06
RFC 4674	Requirements for Path Computation Element (PCE) Discovery	Oct-06
RFC 4368	Multiprotocol Label Switching (MPLS) Label-Controlled ATM and Frame-Relay Management Interface Definition	Jan-06

Recent IP/MPLS Standards Published by IETF Continued…2

RFC 4379	Detecting Multi-Protocol Label Switched (MPLS) Data Plane Failures	Feb-06
RFC 4378	A Framework for Multi-Protocol Label Switching (MPLS) Operations and Management (OAM)	Feb-06
RFC 4377	Operations and Management (OAM) Requirements for Multi-Protocol Label Switched (MPLS) Networks	Feb-06
RFC 4420	Encoding of Attributes for Multiprotocol Label Switching (MPLS) Label Switched Path (LSP) Establishment Using Resource ReserVation Protocol-Traffic Engineering (RSVP-TE)	Feb-06
RFC 4461	Signaling Requirements for Point to Multipoint Traffic Engineered MPLS Label Switched Paths (LSPs)	Apr-06
RFC 4561	Definition of a Record Route Object (RRO) Node-Id Sub-Object	Jun-06
RFC 4687	Operations and Management (OAM) Requirements for Point-to-Multipoint MPLS Networks	Sep-06
RFC 4328	Generalized Multi-Protocol Label Switching (GMPLS) Signaling Extensions for G.709 Optical Transport Networks Control	Jan-06
RFC 4327	Link Management Protocol (LMP) Management Information Base (MIB)	Jan-06
RFC 4394	A Transport Network View of the Link Management Protocol (LMP)	Feb-06
RFC 4397	A Lexicography for the Interpretation of Generalized Multiprotocol Label Switching (GMPLS) Terminology within The Context of the ITU-T's Automatically Switched Optical Network (ASON) Architecture	Feb-06
RFC 4426	Generalized Multi-Protocol Label Switching (GMPLS) Recovery Functional Specification	Mar-06
RFC 4427	Recovery (Protection and Restoration) Terminology for Generalized Multi-Protocol Label Switching (GMPLS)	Mar-06
RFC 4428	Analysis of Generalized Multi-Protocol Label Switching (GMPLS)-based Recovery Mechanisms (including Protection and Restoration)	Mar-06
RFC 4558	Node-ID Based Resource Reservation Protocol (RSVP) Hello: A Clarification Statement	Jun-06

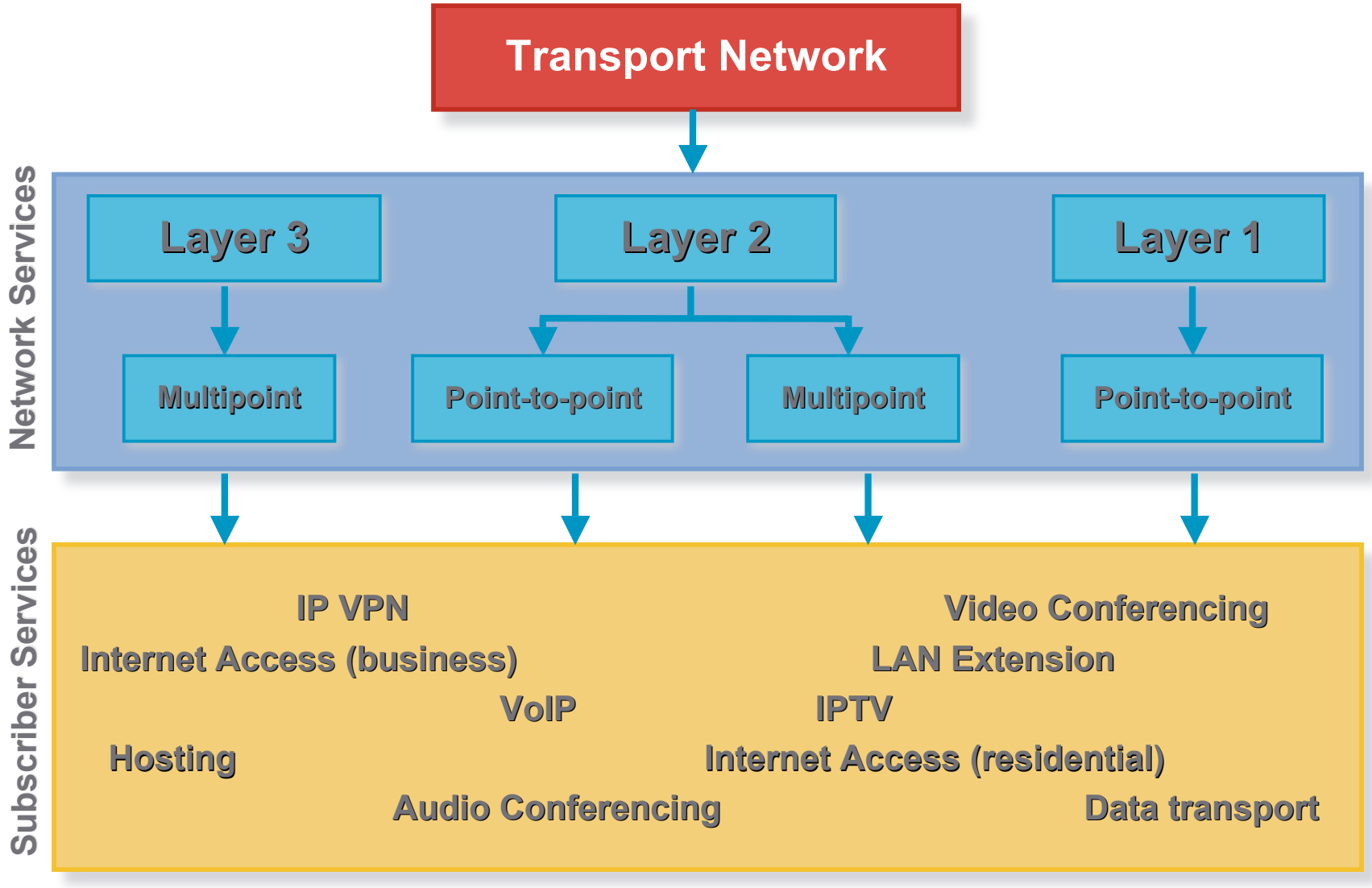
Recent IP/MPLS Standards Published by IETF Continued…3

RFC 4606	Generalized Multi-Protocol Label Switching (GMPLS) Extensions for Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) Control	Aug-06
RFC 4631	Link Management Protocol (LMP) Management Information Base (MIB)	Sep-06
RFC 4652	Evaluation of Existing Routing Protocols against Automatic Switched Optical Network (ASON) Routing Requirements	Oct-06
RFC 4736	Reoptimization of Multiprotocol Label Switching (MPLS) Traffic Engineering (TE) Loosely Routed Label Switch Path (LSP)	Nov-06
RFC 4726	A Framework for Inter-Domain Multiprotocol Label Switching Traffic Engineering	Nov-06
RFC 4783	GMPLS - Communication of Alarm Information	Dec-06
RFC 4221	MPLS Management Overview (I)	Nov-05
RFC 4216	MPLS Inter-AS TE Requirements (I)	Nov-05
RFC 4208	GMPLS User-Network Interface (UNI) (PS)	Nov-05
RFC 4206	LSP Hierarchy with GMPLS (PS)	Oct-06
RFC 4201	Link Bundling in MPLS-TE (PS)	Oct-05
RFC 4127	Russian Dolls Bandwidth Constraints Model for DS-TE (Exp)	Jun-05
RFC 4125	Maximum Allocation Bandwidth Constraints Model for DS-TE (Exp)	Jun-05
RFC 4124	Protocol Extensions for Support of DS-TE (PS)	Jun-05
RFC 4105	Requirements for Inter-Area MPLS TE (I)	Jun-05
RFC 4090	Fast Reroute Extensions to RSVP-TE for LSP Tunnels (PS)	Jun-05

Apart from this list, there are many draft standards that were published in this period which will eventually become new standards in coming months.

Service Mapping and Applicability

Network Service Portfolio



Building Network Services

- What are the important services ?
- What are the transport requirements?
  - Point to Point Transport
  - Multipoint Transport
  - Multicast for Video Delivery
  - Legacy Integration & TDM Circuit Emulation

Multi-vendor Interoperability

- Multi-Vendor Interoperability is key to ensure
  - No Proprietary Implementation is Deployed
  - No vendor Lock-in
  - Investment protection
- Crucial to test Multi-vendor interoperability for critical services/requirements of the network to ensure right selection of technology
  - Traffic protection
  - Services : Point-to-Point, Multipoint-to-Multipoint, Multicast
  - Legacy Integration (e.g. ATM Transport)
  - Quality of Service
  - OAM

Some Historical Background of Layer 3 vs. Layer 2

- In past 10 years, there have been at least 2 major attempts to "revolutionize" networking by introducing a Layer 2 approach with arguments that Layer 3 is either unnecessary, more complex and more expensive –
  - End-to-End Pure Layer 2 Switching
  - ATM LAN Emulation
- Both failed Miserably with time!
- IP/MPLS is revolutionary in a way since it unites the benefits of both Layer 2 and Layer 3 together!

Didn't we finish the L2 vs L3 wars already?

Is a Layer 2 Based Solution Cheaper than a Layer 3 Based Solution ?

Some considerations:

- Cost of overlay networks required for legacy integration
- Cost of network management system
- Cost of overlay network/intelligence required for supporting Multicast and Video
- Cost of manual provisioning & management since network doesn't have intelligent control plane
- Cost of adding Intelligence (GMPLS) to the solution that has no control plane
- Cost of important features on network elements like Hierarchical-QoS (H-QoS), etc

Summary

Summary

Key Points to Consider Before Selecting Technology for Building your Next Generation Ethernet Network

- Technology State, Standardization, Maturity, Field Proven, Future Roadmap
- Network Intelligence: Integrated Control Plane or Proprietary NMS Control Plane
- Is Selected Technology agnostic of transport protocols so that it allows you to migrate smoothly
- Are All Required Services can be offered by the Technology or basic services itself requires workarounds.
- Is technology Multi-Vendor Interoperable
- Last but not the least, its combined capital & operational cost

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