Empowered by Innovation NEC

MPLS-TP Workshop

Part 1: MPLS-TP & PTN Technology Overview and Advantages

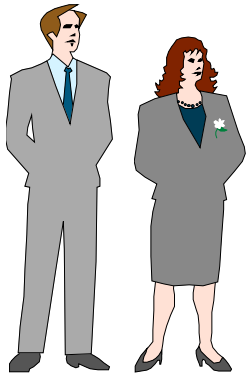
Agenda – Part (1)

MPLS-TP & PTN Technology Overview and Advantages

- MPLS-TP & PTN Technology and its Evolution
  - Major Challenges to service provider and existing technologies
  - What & Why MPLS-TP & PTN?
  - MPLS-TP vs. Others
- MPLS-TP OAM and Standard Progress
  - MPLS-TP OAM overview
  - Standard Progress & two options
  - Hierarchical OAM & Smoothly Migration
- Network synchronization (1588v2 & SyncE)
  - Synchronization requirement of mobile backhaul
  - Clock sync –- SyncEthernet
  - Time sync – 1588v2
- Circuit Emulation in Packet Network (ATM & TDM)
  - TDM (PDH & SDH) circuit emulation
  - ATM Emulation

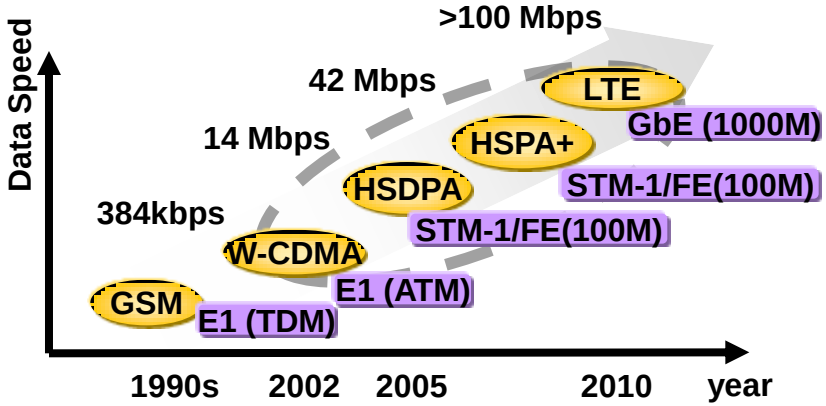
Mobile Data Growth Drivers

Key Catalysts

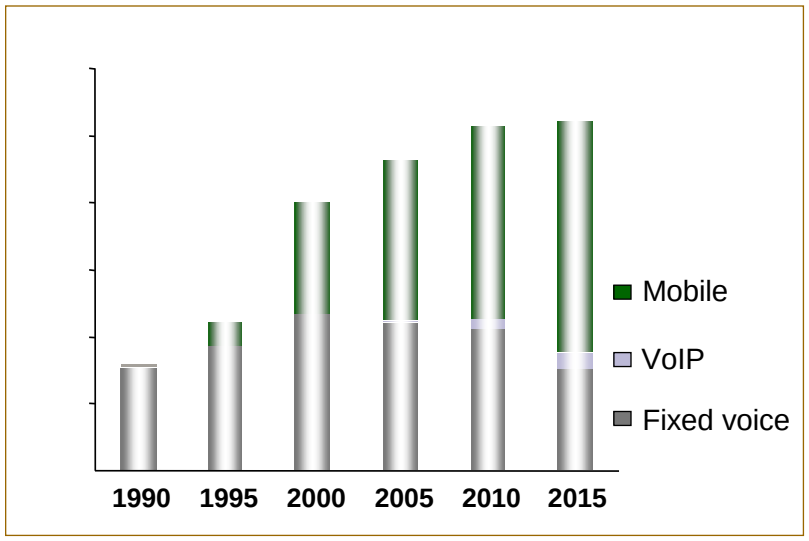


Society

Smart Phones
Internet

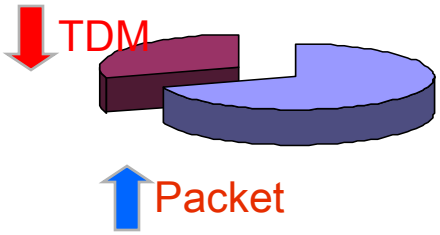


Network & Technology

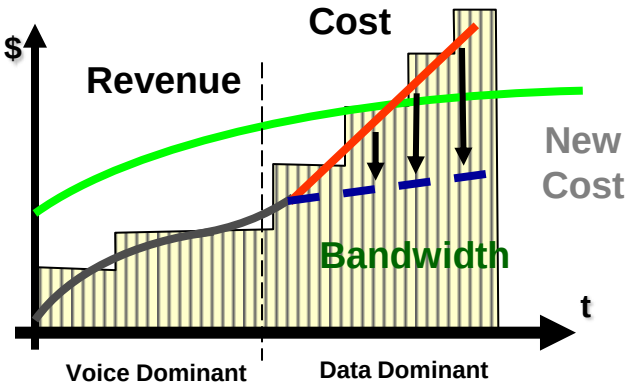


- iPhone, Blackberry, and other smart phones driving the explosive growth in packet traffic
- Mobile carriers have implemented 3G and/or HSDPA to offer much higher data speeds
- HSPA+ and LTE to offer true broadband experience

Major Challenges for Service Providers



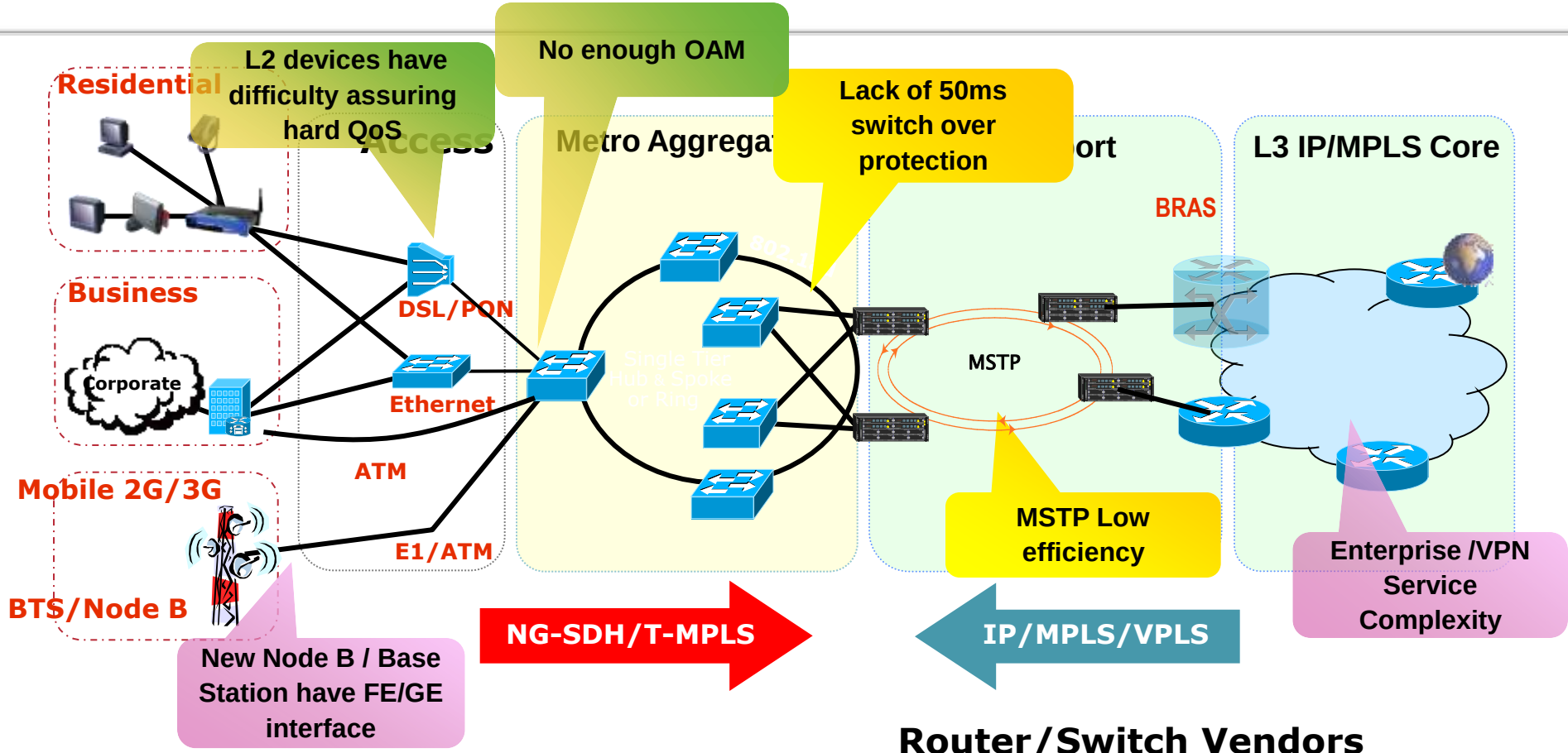
1 **How to deal with Packet Traffic Growth**: Rapid Growth in 3G Mobile and Broadband subscribers worldwide driving the demand for high-speed packet transport



2 **How to improve revenue**: Despite the subscriber growth, ARPU is going down. Networks are too complex, difficult to scale, and expensive to maintain. Energy and Real-estate are another major challenges

3 **How to offer New Services**: Current transport network infrastructure is not adequate to offer evolving mobile services such as LTE and advanced enterprise services (e.g., EPL, EVPL)

Major Challenges for Existing Technologies



Transport Vendors

- Transport based technology
  - Telecom world
  - Connection-oriented, fully controlled by Carrier
- NG-SDH, T-MPLS, RPR
  - Metro aggregation

Router/Switch Vendors

- Router/Switch based technology
  - Internet world
  - Connectionless, loosely controlled, "peer-to-peer", "plug and play"
- IP/MPLS/VPLS
  - Metro core to Metro aggregation

Choices for Service Providers

1 **CONTINUE deploying SDH/ SONET for transport**

But…

- Doesn't scale for packet traffic
- No support for statistical multiplexing – bandwidth inefficient
- High CAPEX

2 **THINK Switch/Router for data Network**

But…

- Connection-less approach
- High OPEX – complex operation Difficult to troubleshoot – weak OAM
- Doesn't meet 3.5G/4G synchronization requirements

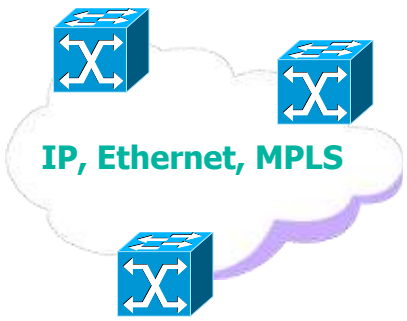
3 **DEPLOY Packet Transport Network**

- **Low TCO**
- Connected Oriented
- Statistical multiplexing; Powerful OAM functions
- Meets mobile synchronization requirements

What is PTN?

Packet Network

- Statistical multiplexing, flexible transport containers
- Service aware
- Advanced QOS
- Scalable
- Cost effective (Ethernet based)



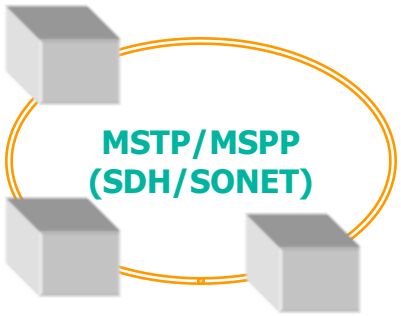
Best of both worlds

Convergence

Packet Transport Network

Transport Network

- Connection Oriented
- High clock accuracy
- Resilient (50ms switch-over)
- Comprehensive OAM
- Multi-service support
- Static or dynamic Provisioning



- Multi-service transport over Packet
- Statistical Multiplexing
- Connection Oriented
- Deterministic data plane
- Hard QoS
- Comprehensive OAM
- Network & equipment protection

Note: PTN is sometimes also referred to as P-OTS or POTP

PTN Technology Choices

PTN Technology Choices

T-MPLS

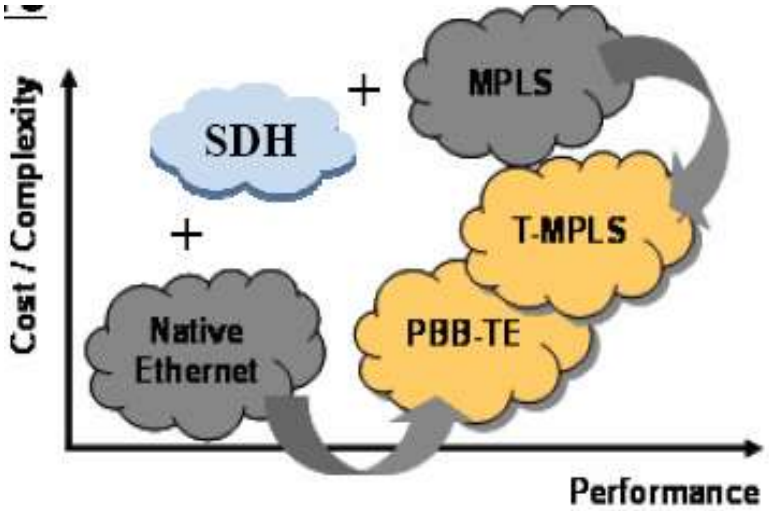
- A new formulation of MPLS, being standardized by ITU-T, and designed specifically for a **connection-oriented packet transport network** based on well-known and widely deployed IP/MPLS technology

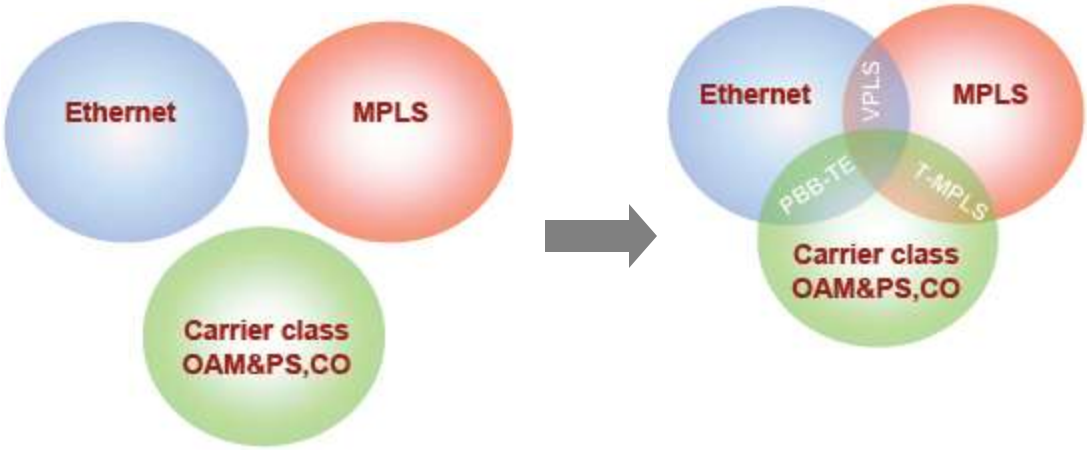
T-MPLS = MPLS (PW/LSP) + OAM – L3 Complexity

PBB-TE

- A subset of IEEE Provider Backbone Bridging (802.1ah) that turns Ethernet connectionless networking into a provisioned connection-oriented transport network primarily for point-to-point Ethernet virtual connections

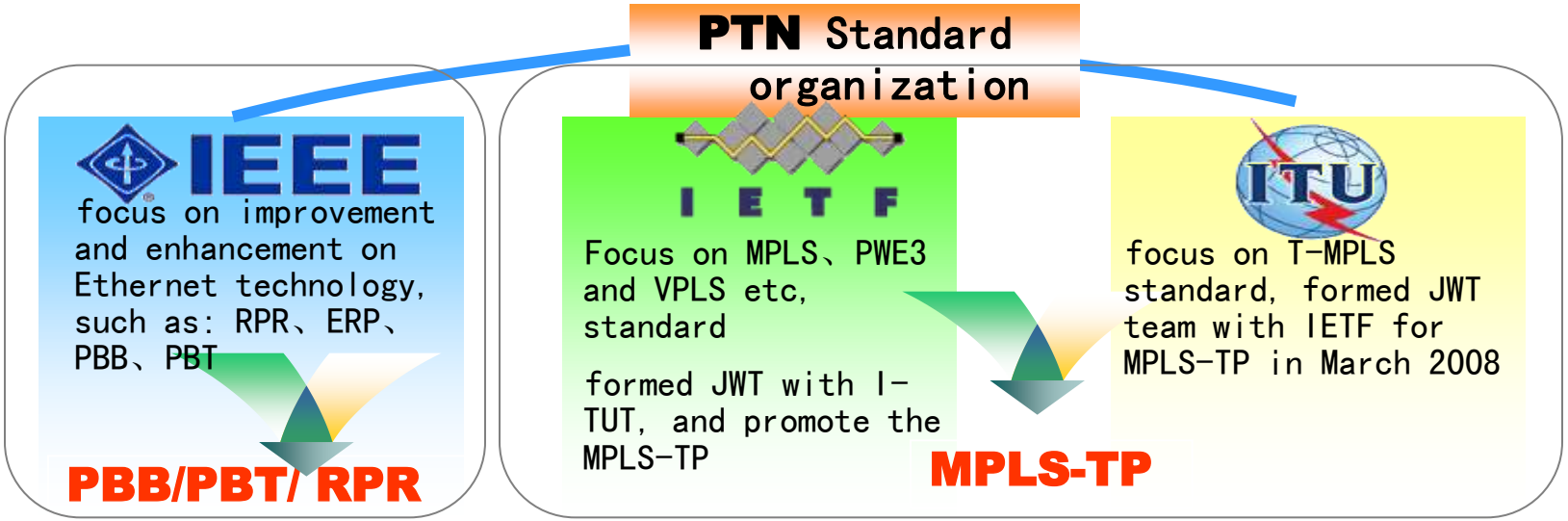
PBT = Ethernet (MAC/MAC)+OAM – L2 Complexity

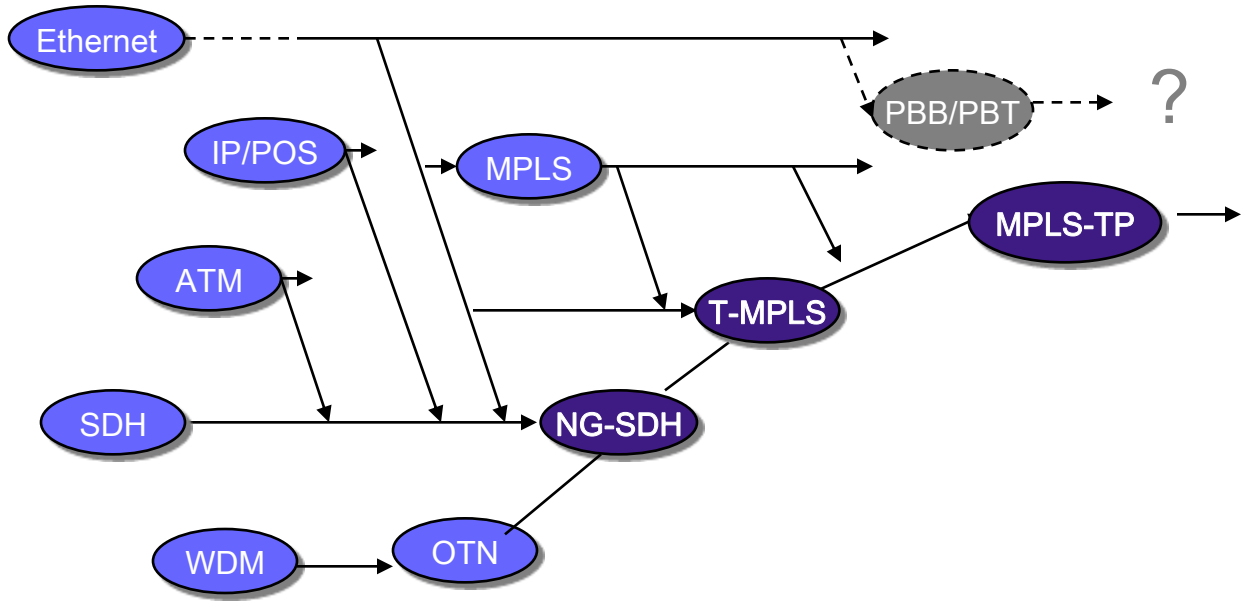




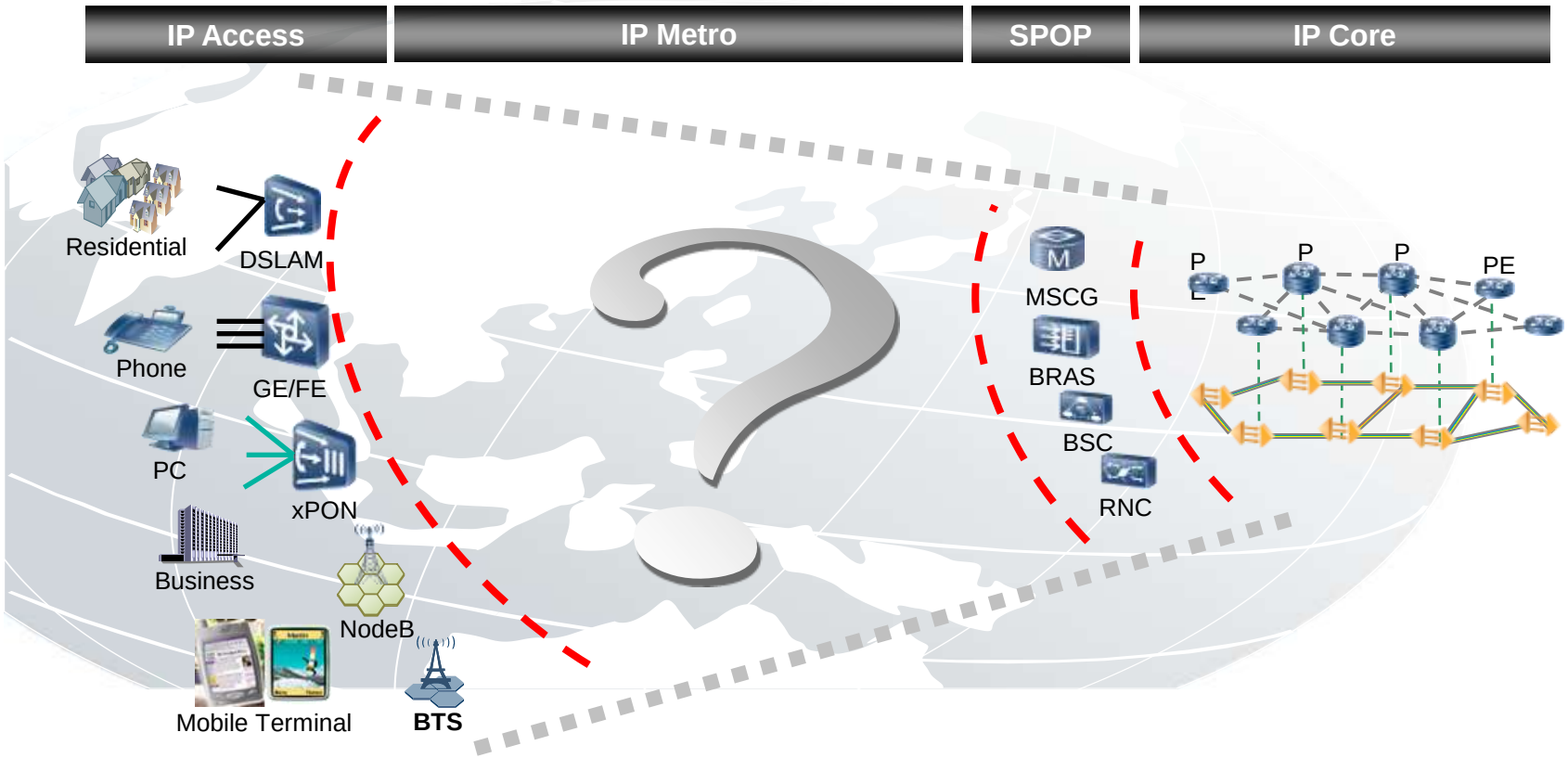
PBT and T-MPLS are major PTN technology choices base on different migration path

PTN Standards Overview





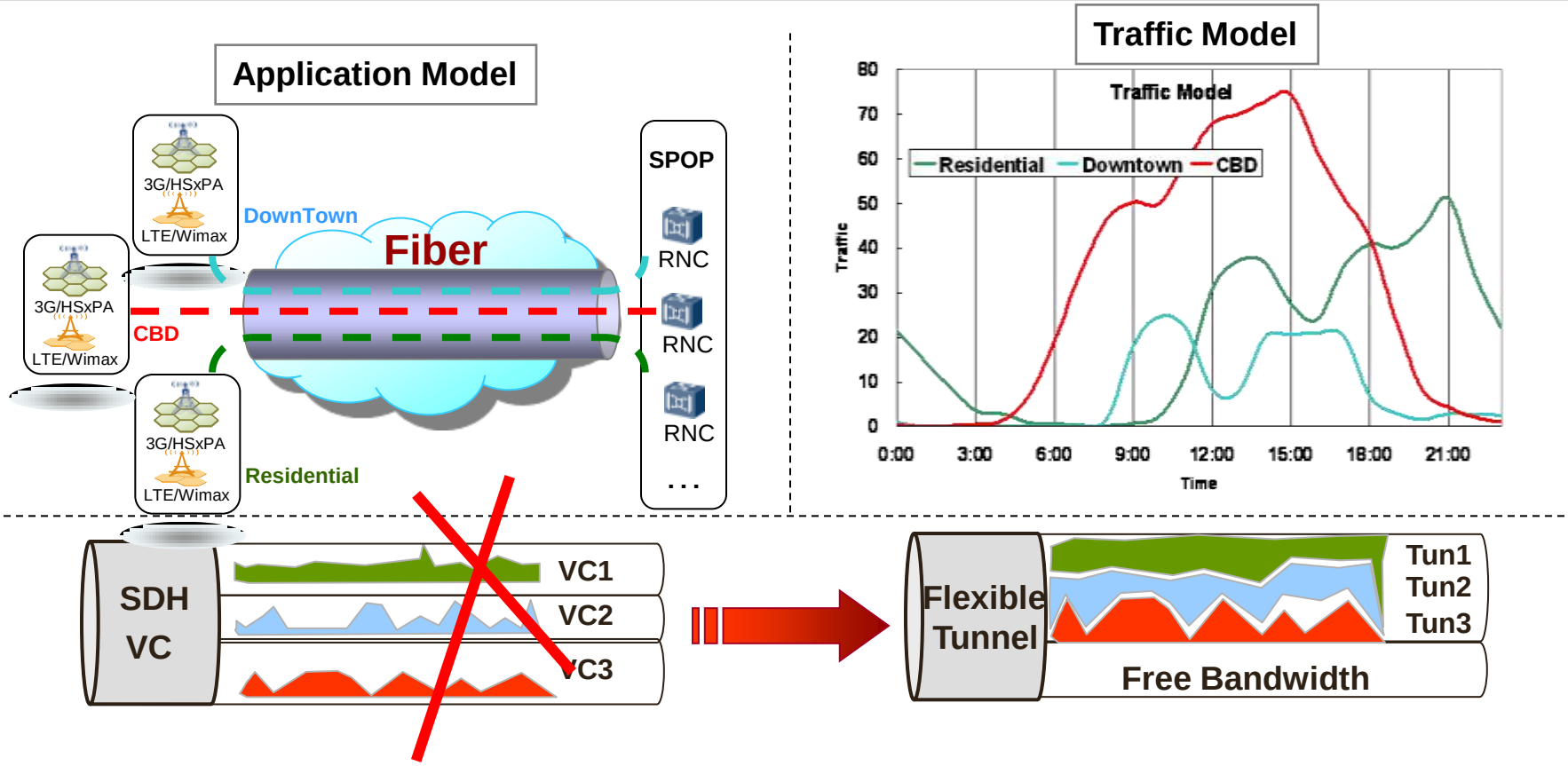
Existing Technologies Hard to meet the challenges



The existing networks hard to meet the challenges:

- **MSTP/SDH:** TDM based, low efficiency of carrying IP, bandwidth monopoly, poor scheduling flexibility
- **Switch:** Lack of OAM fault detection mechanisms, Lack of QoS capacity, weak network management tools, difficult for multi-services and sync support
- **Router:** high cost, weak network protection capability, weak NMS, difficult for voice traffic, sync, high requirement to maintenance engineer…

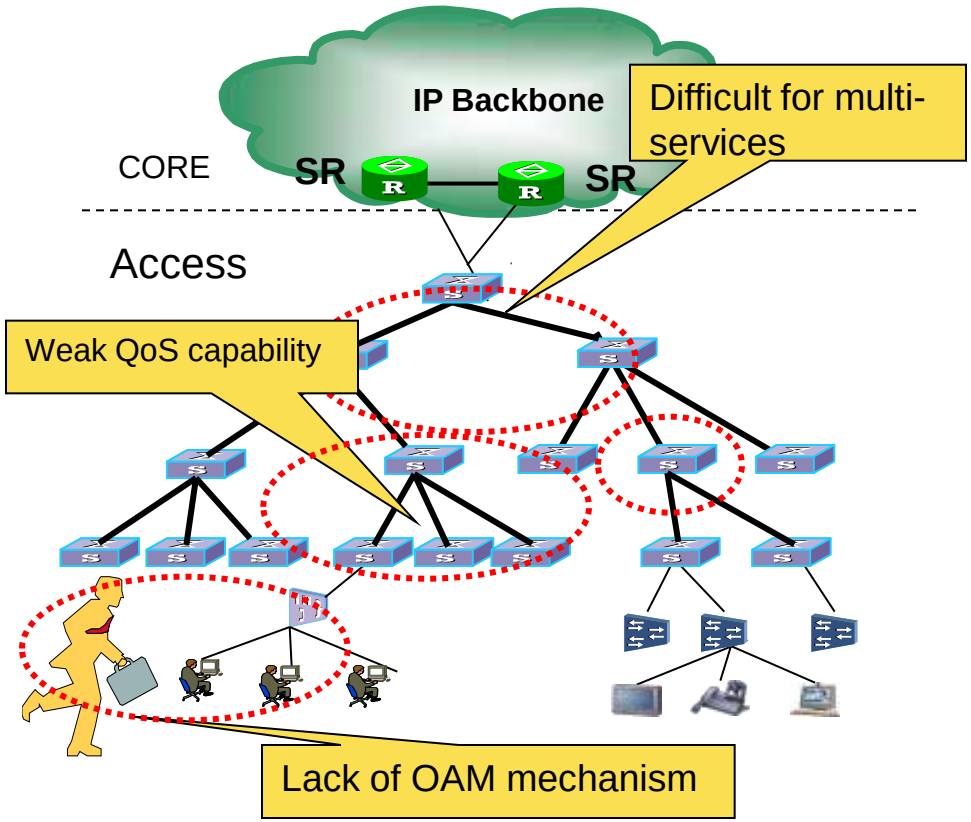
Why not SDH/MSTP?



SDH/MSTP can support both TDM and Ethernet traffic with carrier class reliability and availability through network and device protection, end to end NMS, good OAM and easy operation But……

- Low efficiency, not support static multiplex for future packet base network and traffic
- Without good QoS for Ethernet traffic fair access
- Fixed transport container, difficult to scale…

Why not Lanswitch?



- Connectionless, no end to end QoS mechanism
- Lack of effective network protection mechanism. The longer recovery time is needer for larger network, can't meet the requirements of carrier-class protection switching
- Lack of network management system for operation, maintenance measures
- Lack of OAM mechanism for fault isolation and troubleshooting
- Difficult to support clock and time sync
- Lack of mechanism and difficult to support multi-service special ATM traffic.

Lanswitch is weak at network protection, QoS, OAM, Sync and NMS which is not suitable fore telecom class network.

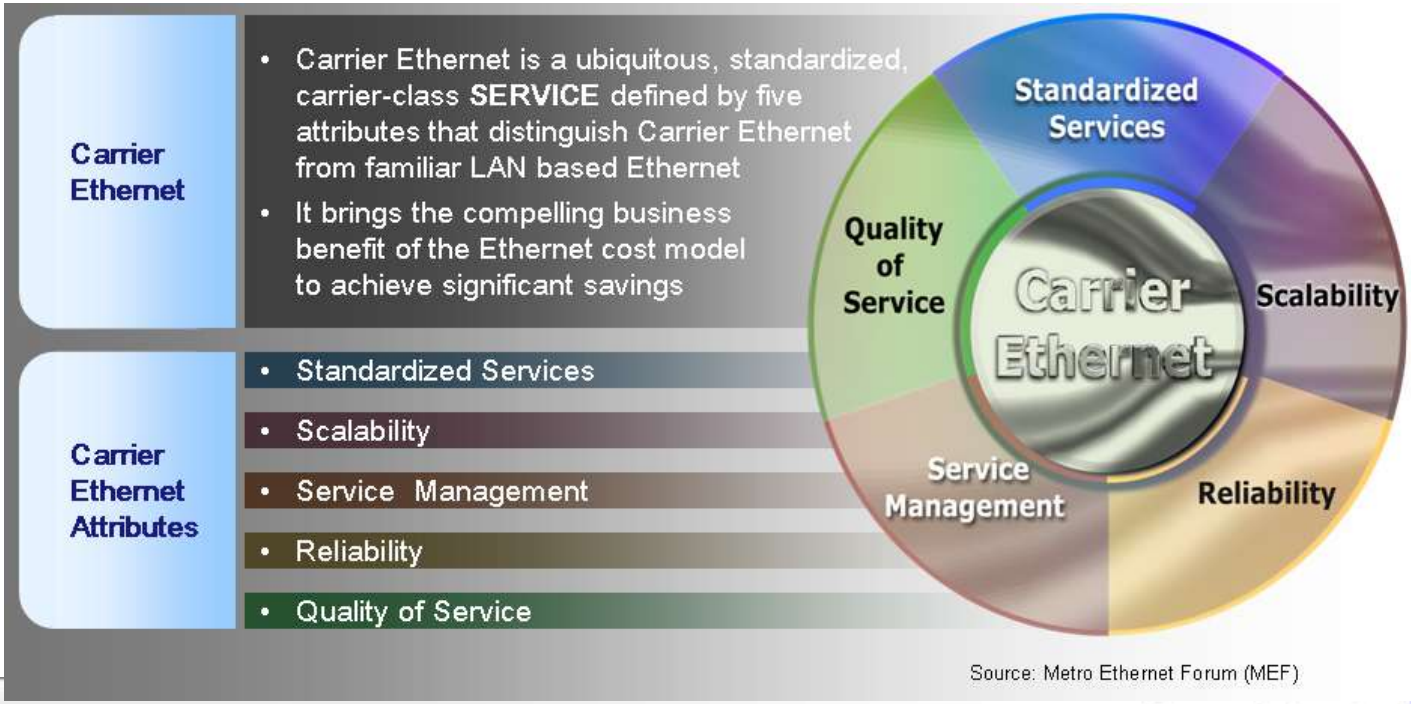
Carrier Ethernet Still Stays On Ethernet

What is Carrier Ethernet (CE)?

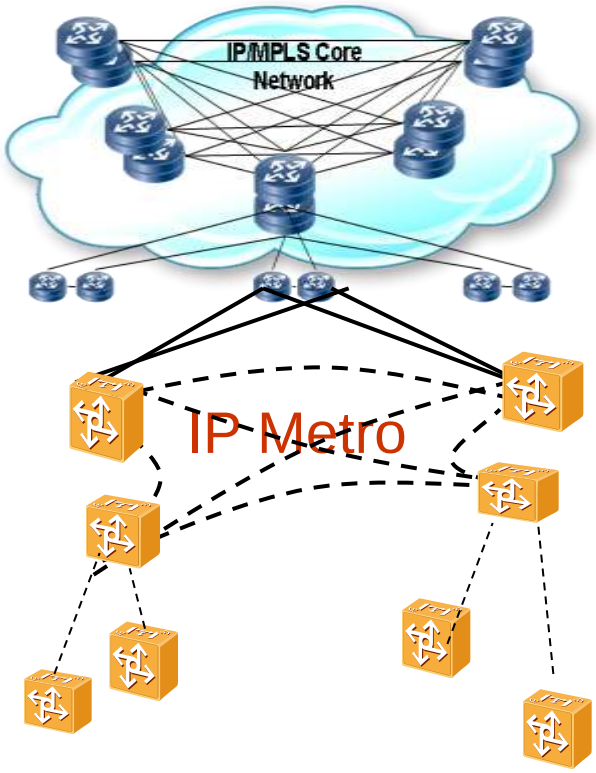
- Traditional Ethernet is a connectionless technical base on L2S, MAC learning, flooding and xSTP which can not extend to Metro network
- Enhancement Ethernet technologies like RPR, PB, PBB/PBT try to extend Ethernet to metro network for carriers applications
- Carrier Ethernet itself is a service defined by MEF as blow.

Current CE Equipment & Solution lack of:

- High clock accuracy
- Hierarchical comprehensive OAM
- Powerful Network management for e2e service provisioning
- Multi-services support
- Connection Oriented, end to end QoS
- Resiliency on par with TDM network at large number of traffic (EVCs)



Why not Router?



Router supports multi-service, support L2/L3 function, support hierarchical scheduling and flow control and ensure high priority services Priority pass. But ...

- Lack of hardware-based OAM, difficlut to meet sub-50ms protection especially simultaneous failures happen
- Weak network management capability, lack of end to end service configuration
- Lack of sync transmission solution
- Weak device level and network level redudancy and protection mechanism
- High cost, but most of features are useless in Metro network like million forwarding table.

Router is lack of Network management, OAM and maintenance, difficult to support sync transmission but high cost at both CAPX and OPEX

MPLS-TP Advantages over IP/MPLS

MPLS-TP Networks are much simpler

- Unlike IP/MPLS, which is dependent upon extremely complex control plane, MPLS-TP connections can be statically configured via Netman
- Enhanced OAM functions enable faster troubleshooting, making the network performance predictable

MPLS-TP is designed for transport networks

- IP/MPLS network operation requires skilled and trained professionals on MPLS (one report from China suggests that an operator requires 10x more people to manage L2/L3 switch/router compared to transport products)
- On the other hand, existing operations team for transport network can be trained easily to operate MPLS-TP products

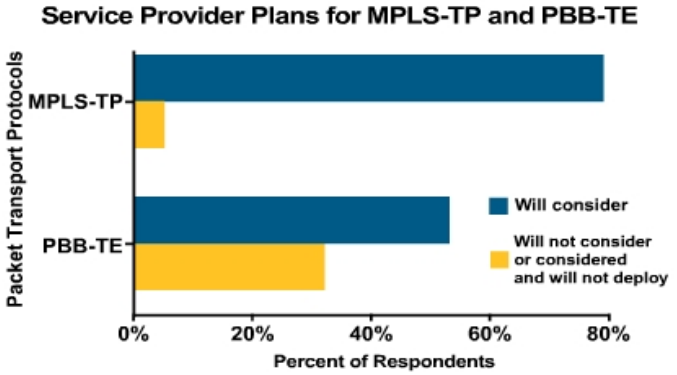
MPLS-TP is ready for Mobile Backhaul

- 3G/LTE needs highly accurate clock. IEEE 1588v2 standard can meet synchronization requirements, however has strict jitter, wander, and delay requirement)
- In mobile backhaul, the multiplication of Pseudowires (PWs) requires IP addresses for the PWs. Thousands of such addresses carried by an IGP is problematic for IP/MPLS.
- Protection based on MPLS-Traffic Engineering (TE) associated with a TE/Fast Reroute (FRR) setup to protect thousands of nodes/paths is huge challenge to IP/MPLS.

MPLS-TP beats PBB-TE

	MPLS-TP	PBB-TE
ITU-T & IETF Joint Effort	Based on IETF & ITU-T Joint effort Work-in-progress at the ITU-T (Study Group 15)	Based on IEEE PBB 802.1Qay standard
Multi-service Capabilities	Designed to carry SDH, PDH, ATM, and IP over Ethernet (Connection-oriented, High clock accuracy Enables smooth migration of legacy SDH/SONET networks to pure-packet	More suitable for carrying Ethernet based services, e.g., PW needed for non-IP traffic Major issues in handling multicast and VPLS applications
Carrier Preference	SBB, China Mobile, Oi, and many others planning to go with T-MPLS/MPLS-TP	British Telecom has deemphasized PBB-TE Verizon may not stay with PBB-TE

- MPLS-TP came out as an undisputed winner
- Carrier survey which included participation from incumbent and competitive operators in North America, EMEA, and Asia Pacific shows MPLS-TP is much more interested.
- Much broader vendors select MPLS-TP and develop their product launch to the market

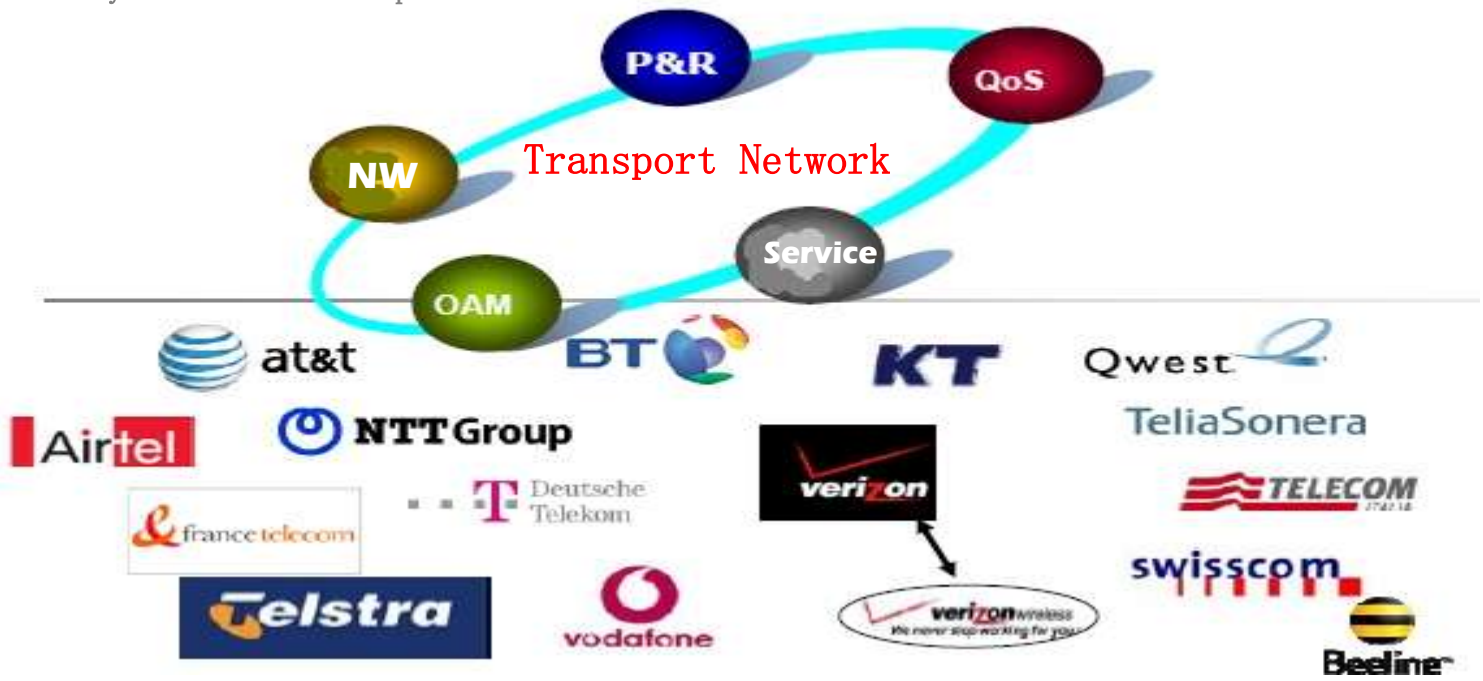


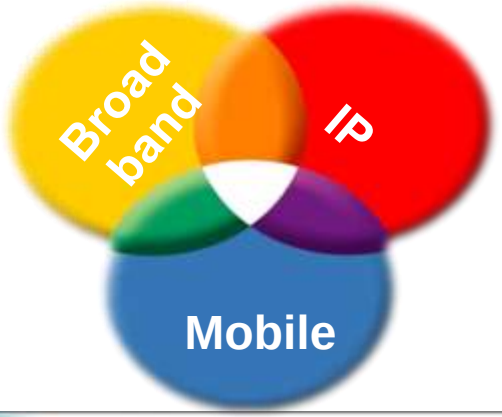
© Infonetics Research, *MPLS-TP and PBB-TE Go Toe-to-Toe: Service Provider Survey* (Continuous Research Service) December 2008

Global Operator Moving to Packet Network

Global Operators Moving to Packet Network

Key Factors in Transport Network





The deployment of Packet transport network (PTN) is the one of key factor of success in global operators packet migration

MPLS-TP Origins/History

- T-MPLS in ITU-T
  - ITU-T designed a connection-oriented packet switched technology to be used in Transport Networks to provide wide area connectivity upon which other services, such as IP or the phone network, run. The ITU-T chose to adapt the IETF's MPLS to this task, and introduced a protocol suite known as T-MPLS.
- Liaison exchanges between the ITU-T and the IETF
  - Number of liaison between ITU-T and IETF, the IETF became increasingly concerned that the incompatibility of IETF MPLS and ITU-T T-MPLS would "represent a mutual danger to both the Internet and the Transport network".
- Two options proposed by the chairs of the IESG and IAB
  - Option 1: T-MPLS should become fully compliant MPLS protocol, standardized under the IETF process (the so-called "Option 1")
  - Option 2: It should become a completely disjoint protocol with a new name and completely new set of code points (the so-called "Option 2") [Ethertypes].
  - It was discussed at an ITU-T meeting of Question 12 Study Group 15 in Stuttgart [Stuttgart], where it was proposed that a Joint (ITU-T - IETF) Team should be formed to evaluate the issues, and make a recommendation to ITU-T management on the best way forward.
  - Following discussion between the management of the IETF and the ITU-T, a Joint Working Team (JWT) was established;

MPLS-TP Overview

MPLS-TP

Management Plane:
- Statically configure LSP and PW and manage via NMS
- OAM handling

Control Plane:
- **Optional**
- LSP, PW, and OAM not dependent upon control plane
- Static provisioning via NMS;
- *Dynamic Provisioning (e.g., LSP: RSVP-TE, GMPLS, PW: RFC 4447) under study*

Data Plane:
- Fully compatible with MPLS
- Forwarding based on LSP/PW Label
- Bi-directional path (LSP) for traffic and OAM
- OAM support via Associated Channel (PW ACH & GE ACH)
- MPLS based Protection mechanism
- Pseudo-wire encapsulation for all traffic types (Ethernet, ATM, SDH/SONET, and PDH)
- Transport hierarchy similar to SDH/SONET – nested PW and LSP

NMS

Control Plane

Working-Group Focus Areas

Protection

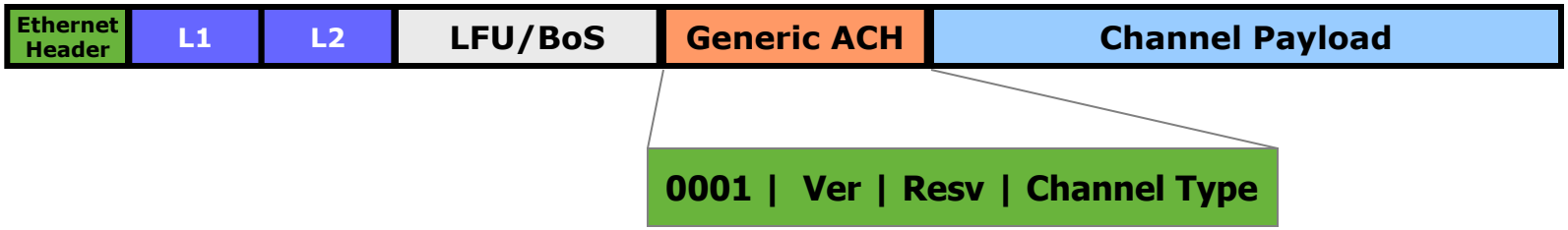
OAM

Forwarding

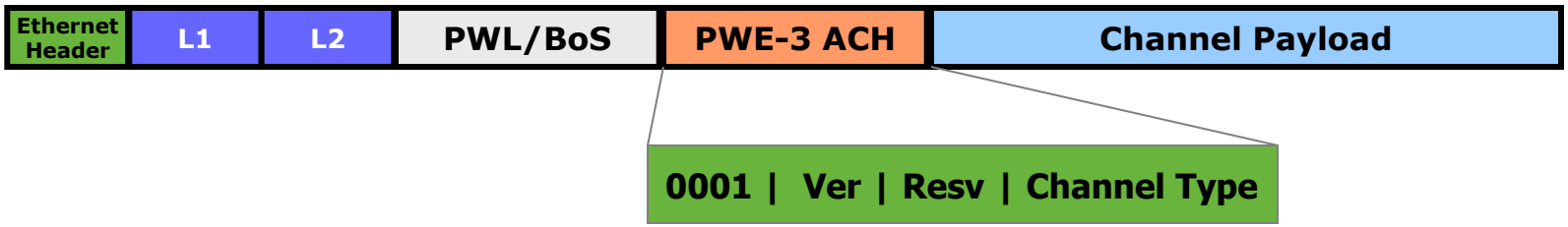
Comprehensive & Hierarchical OAM in PTN

- **Based on Ethernet, ITU-T, and MPLS-TP standards**
- **Multi-layer OAM support**
  - Client Layer: ATM, SDH/SONET, and Ethernet
  - MPLS-TP Layer: PW and LSP (*using associated channel mechanism as shown below*)
  - Network Uplink layer: Ethernet and SDH/SONET

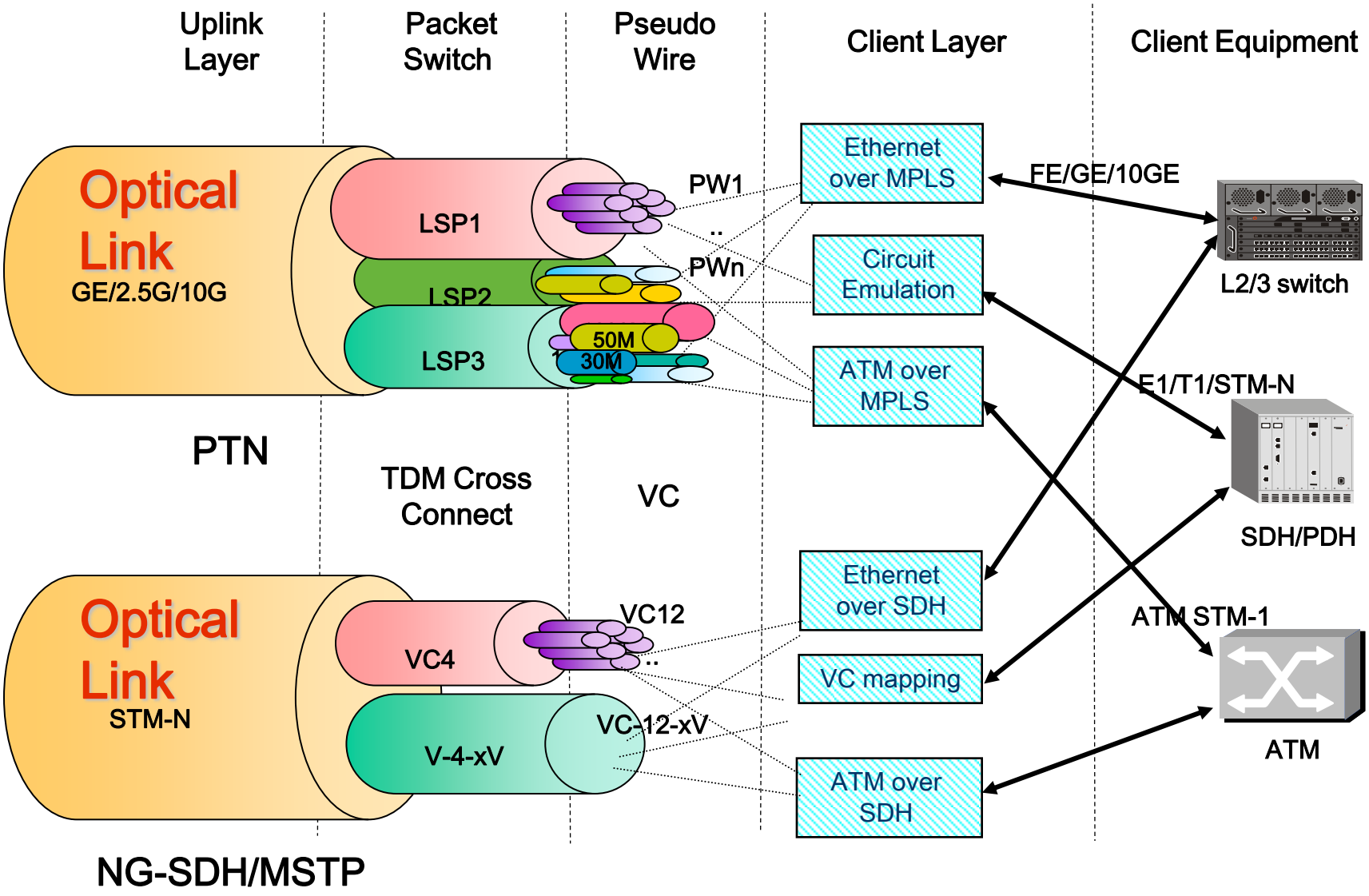
LSP monitoring and alarming
Generic Exception Label and Generic Associated Channel
Many options including Non IP BFD is an option encapsulation of Y.1731 pdu



Pseudo-wire monitoring and alarming
PW-Associated Channel

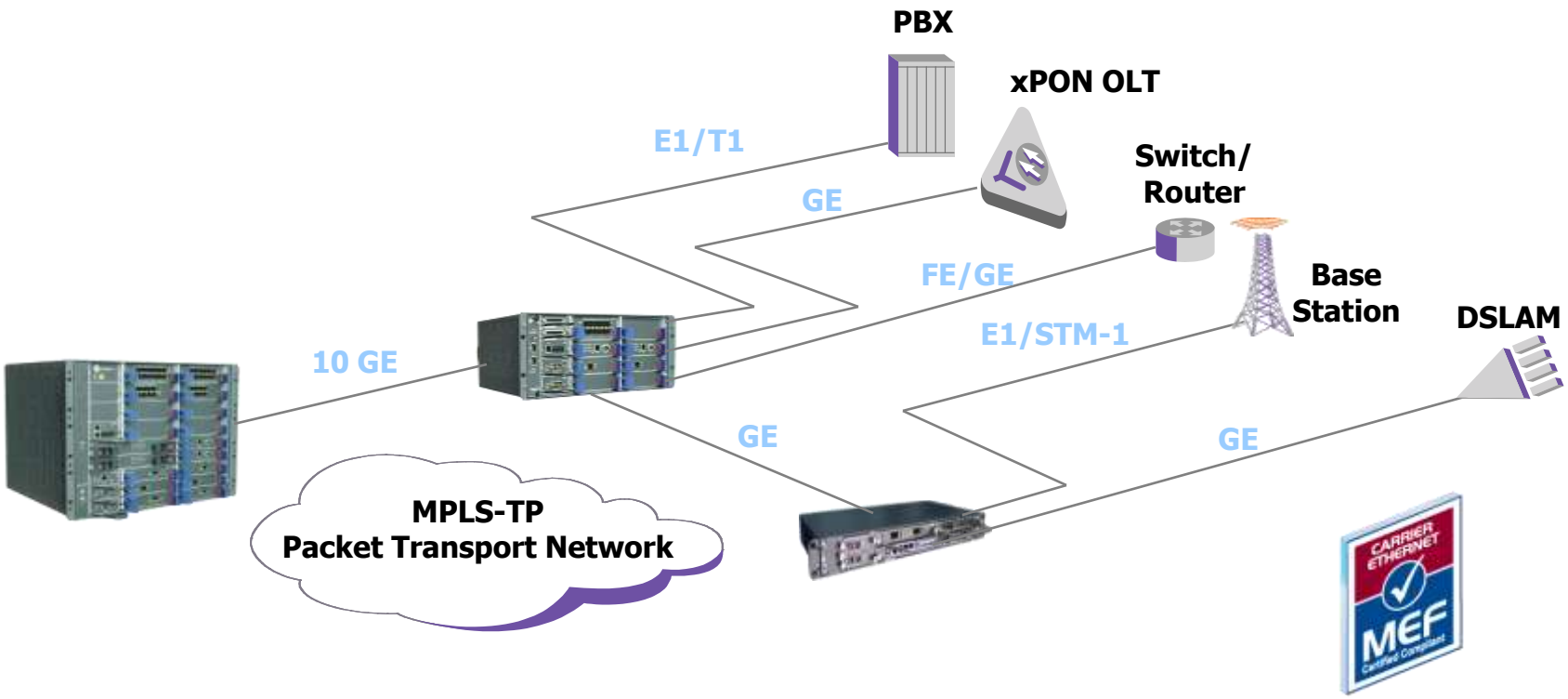


Same Transport Concept as NG-SDH/MSTP for Multi-services



Where Does it Fit

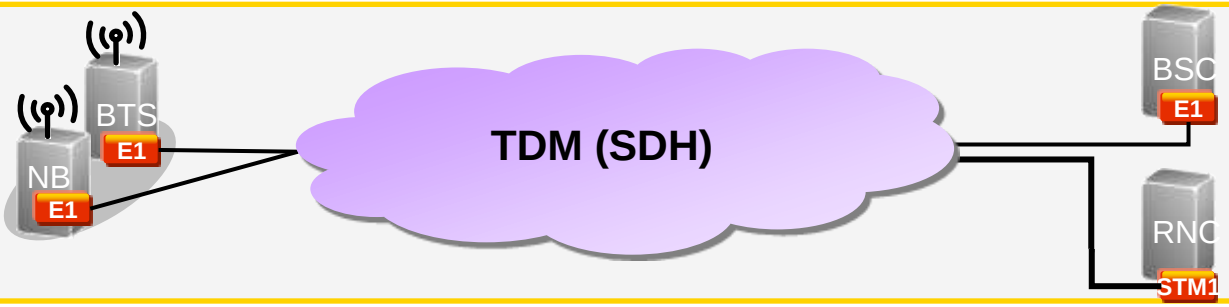
- **Packet transport networks are an emerging segment of the overall optical transport market**
- **PTN Enables variety of service applications**
  - Mobile Backhaul for 2.5G, 3G, and LTE
  - Enterprise VPN Services
  - Broadband Service aggregation



SDH/MSTP Replacement

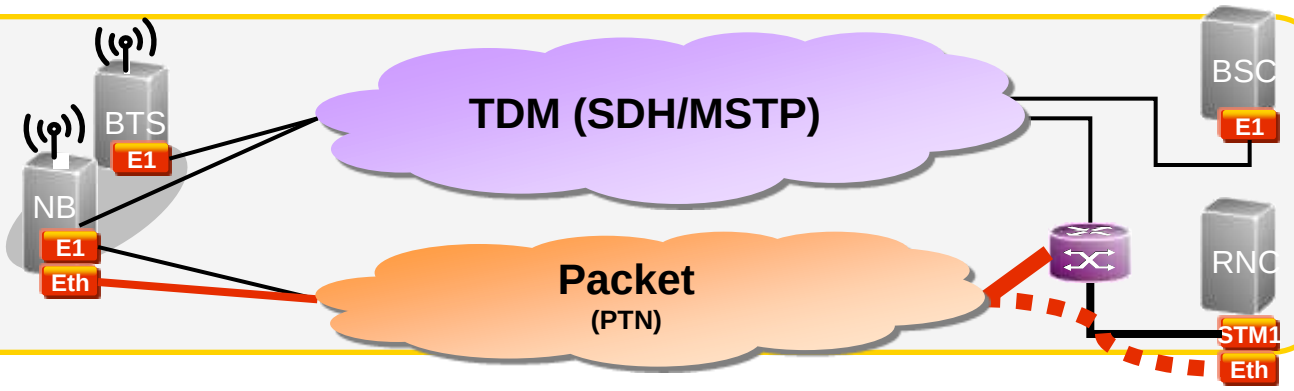
Classic

2G, 3G, HSDPA, LTE, …



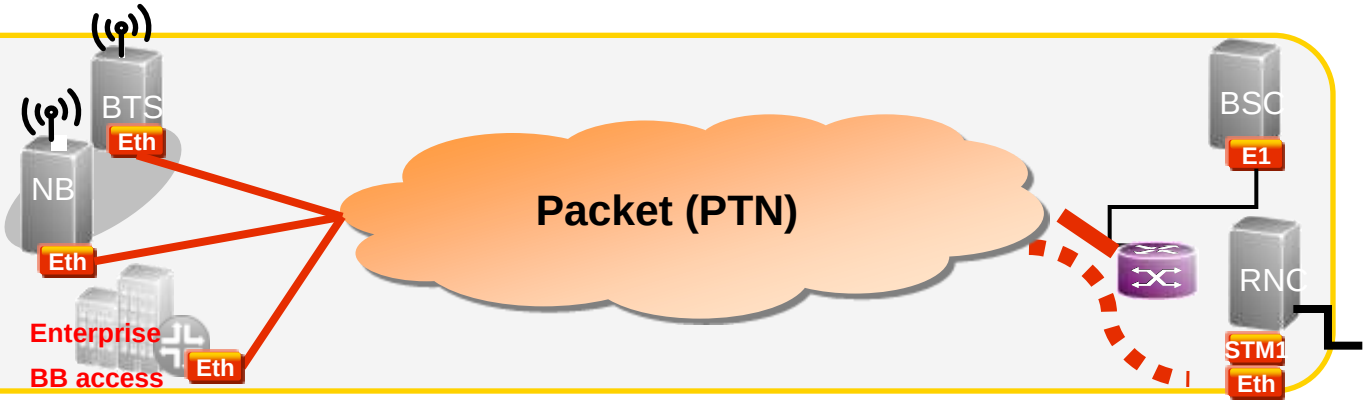
Hybrid

2G, 3G, HSDPA, LTE, …



Packet

2G, 3G, HSDPA, Broadband Aggregation, Enterprise, LTE, …



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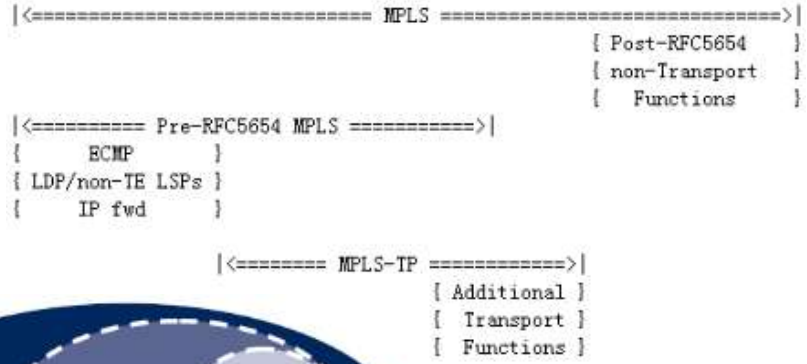
MPLS-TP OAM Overview

OAM (Operation, Administration, and Maintenance) Basic Roles

- Fault Detection & diagnostic: Continuity Check/Connectivity Verification (CC/CV), Loopback (LB)
- Alarm and Alarm suppress: Generate alarm when fault happens but suppress large volume alarm through AIS/RDI (Alarm Correlation Suppression)
- Performance monitor: packet loss ratio (LM), delay measurement (DM)
- Maintenance tools: Link track (LT), Lock (LCK)
- APS OAM: Linear and Ring APS

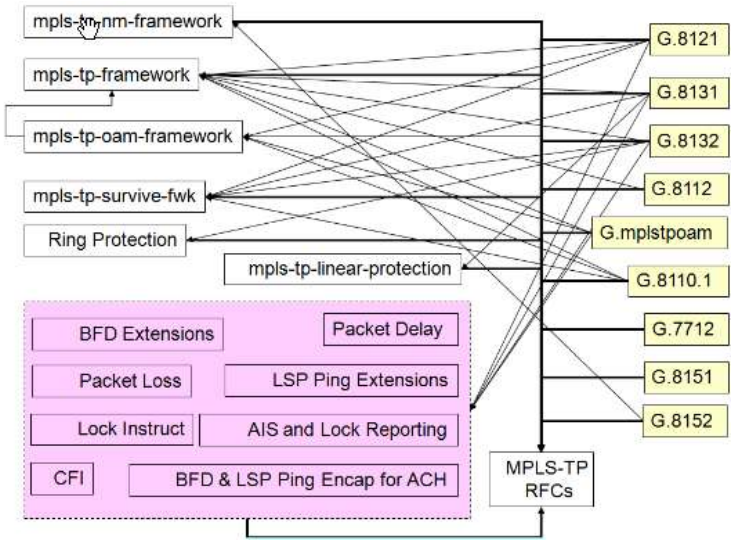
MPLS-TP OAM with IETF and ITU-T

- ITU-T and IETF in many technical aspects of the compromise, MPLS-TP OAM inherited the T-MPLS G.8114 part of the agreement, but the rest of codes and protocols supplementary part, by the major inheritance from the IETF.



MPLS-TP & MPLS

MPLS-TP & T-MPLS G.8114



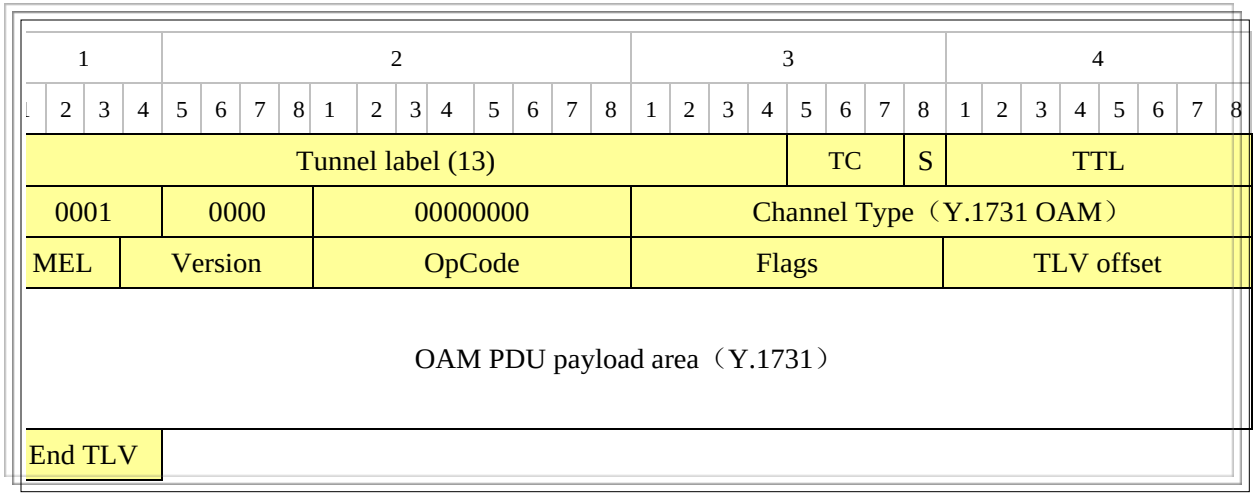
MPLS-TP OAM Standard Progress Update(1)

CLASS	NAME	SOURCE	STATUS	DATE
Requirement	The Requirement of MPLS-TP OAM	A-L/Juniper/M. Betts	RFC5860	2010-05
Framework	MPLS-TP OAM Framework draft-ietf-mpls-tp-oam-framework-09	A-L/BT/Ericsson	RFC Ed Queue	2011-02-18
Concept	"The OAM Acronym Soup" draft-ietf-opsawg-mpls-tp-oam-def-07	Ericsson/ Huawei/Juniper/Avaya	RFC6291	2011-06
Analysis	MPLS-TP OAM Analysis draft-ietf-mpls-tp-oam-analysis-02	NSN/Ericsson	I-D Exists	2011-06-21
	Telecom operator considerations of MPLS-TP OAM draft-fang-mpls-tp-oam-considerations-00	CATR/CMCC/TI/CT/CU	I-D Exists	2011-7-11
Encapsulation	MPLS Generic Associated Channel	A-L/Cisco	RFC 5586	2009-09
	The definition of ACH TLV architecture draft-ietf-mpls-tp-ach-tlv-02	Cisco/Juniper	Expired	2010-3-5
	The package of LSP-Ping and BFD draft-ietf-mpls-tp-lsp-ping-bfd-procedures-00	Juniper/BT/NSN	Expired	2010-08-22
Identifier	MPLS-TP Identifiers draft-ietf-mpls-tp-identifiers-02	A-L/Cisco	RFC Ed Queue	2011-07-22
	MIP MPLS-TP OAM packet process draft-farrel-mpls-tp-mip-mep-map-03	Huawei/Hitachi	I-D Exists	2011-07-11
	MPLS-TP OAM maintenance draft-koike-ietf-mpls-tp-oam-maintenance-points-01	NTT/DT	Expired	2010-03-09
Fault Management	MPLS-TP Fault Management OAM draft-ietf-mpls-tp-fault-02	Cisco/Ericsson/ A-L/Juniper	AD Evaluation	2011-08-15

MPLS-TP OAM Standard Progress Update(2)

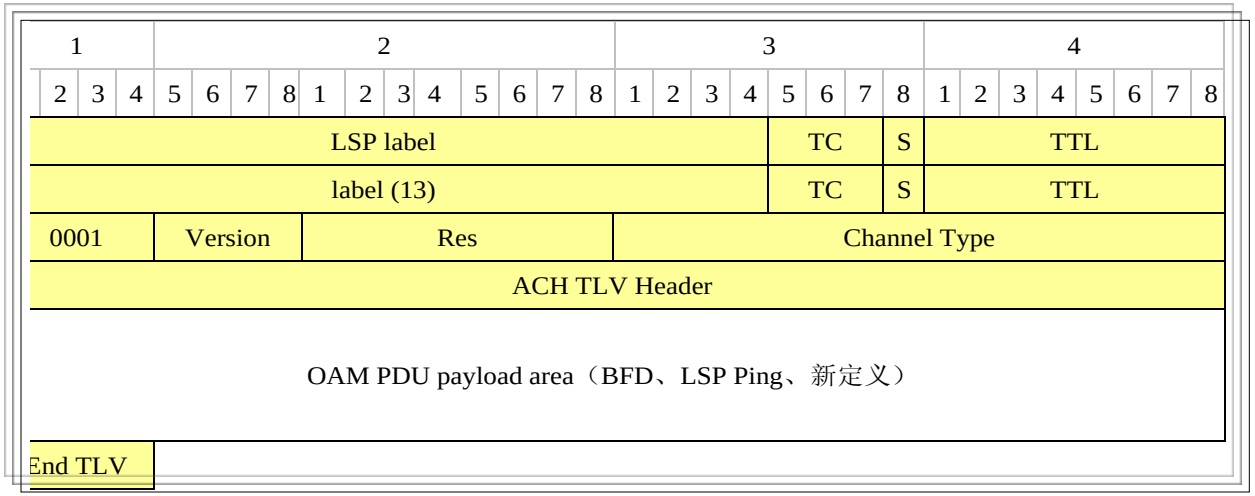
CLASS	NAME	SOURCE	STATUS	DATE
OAM tool	MPLS-TP OAM Primer draft-sprecher-mpls-tp-oam-primer-01	NSN/ Ericsson	Expired	2010-07-05
OAM Total Solution	**MPLS-TP OAM base on Y.1731 draft-bhh-mpls-tp-oam-y1731-05**	**A-L/Huawei**	**I-D Exists**	2011-07-11
Proactive CC/CV/RDI	MPLS-TP Proactive CV/CC and RDI draft-ietf-mpls-tp-cc-cv-rdi-01	Ericsson/Cisco/ Juniper	RFC Ed Queue	2011-08-09
on-demand CC/CV	MPLS on-demand CV, route trace and NF draft-nitinb-mpls-tp-on-demand-cv-00	Juniper/Cisco/Ericsson /	IESG Evaluation	2011-08-10
	LSP Ping configuration for Proactive PLS-TP OAM draft-absw-mpls-lsp-ping-mpls-tp-oam-conf-00	Ericsson/ Juniper	I-D Exists	2011-07-11
Loopback and Lock Indicator	MPLS-TP LSP loopback draft-boutros-mpls-tp-li-lb-01	Cisco/Juniper/AL/ ZTE	I-D Exists	2011-08-15
Lock	draft-fulignoli-mpls-tp-ais-lock-tool-01	Ericsson/NS	Expired	2009-07-13
Path trace	draft-boutros-mpls-tp-path-trace-00	Cisco	Expired	2009-07-06
Diagnostic tool	MPLS-TP diagnostic test tool draft-flh-mpls-tp-oam-diagnostic-test-01	AL/CMCC/CTC	I-D Exists	2010-05-11
Performance	MPLS-TP packet loss and delay measurement draft-ietf-mpls-tp-loss-delay-00	Cisco	RFC Ed Queue	2011-07-19
	Extension of packet loss counting active/de-active draft-xiao-mpls-tp-lm-counting-extension-00	ZTE	Expired	2010-07-05
	MPLS-TP Throughput estimation draft-xiao-mpls-tp-throughput-estimation-01	ZTE	I-D Exists	2011-03-29
Client Signal Failure	draft-he-mpls-tp-csf-02	Huawei/CMCC	I-D Exists	2011-03-14

OAM Options:
G.Ach+Y.1731 vs. BFD/LSP Ping Extension



Y.1731 frame format：

- use MPLS date plane (Label: 13)
- Use G.ACH
- use **OpCode** identify OAM type



BFD extensions frame format：

- Use MPLS date plane (Label: 13)
- Use G.ACH
- use **Channel Type** identify OAM type

- **Y.1731 has better fault detection function but limited in L2 and below**
- **BFD expansion can support fault detection up to L3 and below**

MPLS-TP OAM Functions and Implementation

Class	Type	Function	T-MPLS G.8114	MPLS-TP (draft-bhh-Y.1731)	MPLS-TP (9 other drafts,BFD)
Multi-ownership	Degree	Network, multi-domain link	n*8	Label stacking	Label stacking
Proactive	Status	Continuity Check	CV.CC	CCM.CC	BFD async+ext.[WIP]
		Connectivity Verification	CV(TTSI)	CCM(MEG-IG+MEP-ID	BFD extensions[WIP]
	Performance	Broken	CV.CC,CV.RDI	CCM.CC, CCM.RDI	BFD status+ext.[WIP]
		Frame loss	CV.LM	CCM.LM, LMM/LMR	New PM tool[WIP]
	Maintenance	Alarm supress	FDI	AIS	New PM tool[WIP]
		Lock Indication	LCK	LCK	New PM tool[WIP]
		Remote failure indication	CV.RDI	CCM.RDI	BFD diag extensions[WIP]
		Client signal idication	CSF	CSF	New PM tool[WIP]
on-demand	Status	Connectivity Verification	LBM/LBR	LBM/LBR	LSP Ping extensions[WIP]
	Performance	Frame loss	LMM/LMR	LMM/LMR	New PM tool[WIP]
		Frame Delay	DMM/DMR,1DM	DMM/DMR,1DM	New PM tool[WIP]
		Frame Delay Variance	DMM/DMR,1DM	DMM/DMR,1DM	New PM tool[WIP]
		Throughput	LBM/LBR,TST	LBM/LBR,TST	New tool[WIP]
	Failure Isolation	Path Connectivity	LBM/LBR	LBM/LBR	LSP Ping extensions[WIP]
		Stream Connectivity	-	-	LSP Traceroute ext.[WIP]
Communication Channel	Protection	head/tail-end sync	APS	APS	New PSC tool[WIP]
	General	ECC for MCN/SCN	MCC,SCC	MCC,SCC[RFC5718]	MCC,SCC[RFC5718]

China Operators and Vendors push G.ach +Y.1731 Option

CMCC/China CCSA select G.ach +Y.1731 as PTN OAM standard

- Treat draft-bhh-mpls-tp-oam-y.1731 as option of MPLS-TP OAM
- Y.1731 Ethernet OAM: 0x8902
- Select RFC5586 experimental Code Point **32767 (7FFF)** as channel type
- Alliance:
  - PTN vendor: Al-Lu, Huawei, ZTE, Fiberhome, UTS, etc.
  - Operators: China Mobile, China telecom, China Unicom, TI, CJK, telefonica etc.
- Push the acceptance and standard process in ITU-T and IETF

Option 1: GACH+Y.1731

- Mature, meet all the requirement at technical point of view
- Easy upgrade from existing PTN system to support this Mechanism
- Better availability, Large volume PTN deployed in CMCC and most PTN equipment can upgrade to to support it in short term

Option 2: MPLS-TP & MPLS

- Not complete and not mature, can not meet short term requirements (at least another 2 years to be mature)
- Hard to upgrade from existing PTN system to support this mechanism, hardware upgrade might be necessary
- Consensus and might be final standard at last
- No equipment or vendor declare support it

Migration to MPLS-TP OAM

MPLS-TP standards Progress

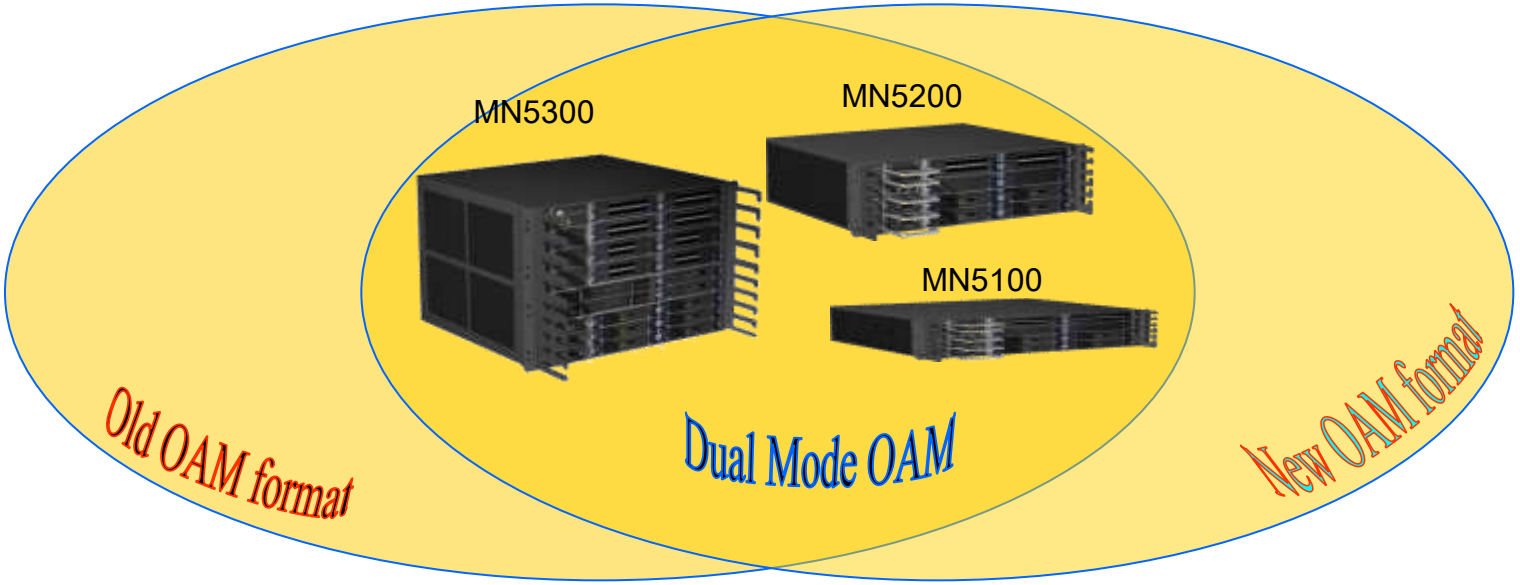
- Standards still in development by the JWT from ITU-T and IETF.
- MPLS-TP is based on PWE3 and LSP forwarding architecture which is within IETF MPLS standards. So there are minimal changes in the LSP and PW data-structure

Upgrading to MPLS-TP OAM

- More comprehensive OAM features to handle the end-to-end management of network than IP/MPLS.
- MPLS-TP OAM standards are still under development, hence current installed equipment will have to be upgraded to support the new OAM formats and messages to comply with Standard

NEC will ensure smooth migration to MPLS-TP OAM without any service disruption

MN5000 OAM Upgrade Scenario



- When MPLS-TP OAM standards are finalized, TN series can be upgraded to work on dual OAM formats simultaneously (Dual-Mode): one mode supports the old format, and another one supports the new format that complies with the finalized MPLS-TP standards.
- The whole upgrade process is divided into two steps:
  1. upgrade each node to support dual OAM formats
  2. activate the LSP to support new OAM format.

Agenda – Part (1)

MPLS-TP & PTN Technology Overview and Advantages

- MPLS-TP & PTN Technology and its Evolution
  - Major Challenges to service provider and existing technologies
  - What & Why MPLS-TP & PTN?
  - MPLS-TP vs. Others
- MPLS-TP OAM and Standard Progress
  - MPLS-TP OAM overview
  - Standard Progress & two options
  - Hierarchical OAM & Smoothly Migration
- Network synchronization (1588v2 & SyncE)
  - Synchronization requirement of mobile backhaul
  - Clock sync –- SyncEthernet
  - Time sync – 1588v2
- Circuit Emulation in Packet Network (ATM & TDM)
  - TDM (PDH & SDH) circuit emulation
  - ATM Emulation

Synchronization Requirements for Mobile Networks

- SDH/SONET Synchronization (ITU G.813)
  - Free run: ± 4.6ppm
  - Holdover: ± 0.37ppm within 24 hours
- Mobile Backhaul Clock
  - Holdover clock accuracy: ±0.05ppm within 24 hours
  - WCDMA TDD mode，phase difference for inter-cell ± 2.5us
  - CDMA2000 mode，phase difference for inter-cell ± 10us (each cell relative to UTC 3us)
- Network Synchronization over packet networks
  - Sync Ethernet
  - IEEE 1588v2 (Time over Packet)

Mobile Technology	Clock Frequency	Timing Phase
GSM	0.05ppm	NA
WCDMA	0.05ppm	NA
CDMA2000	0.05ppm	3μs
TD-SCDMA	0.05ppm	1.5μs
WiMAX	0.05ppm	1 μs
LTE	0.05ppm	Time sync is required

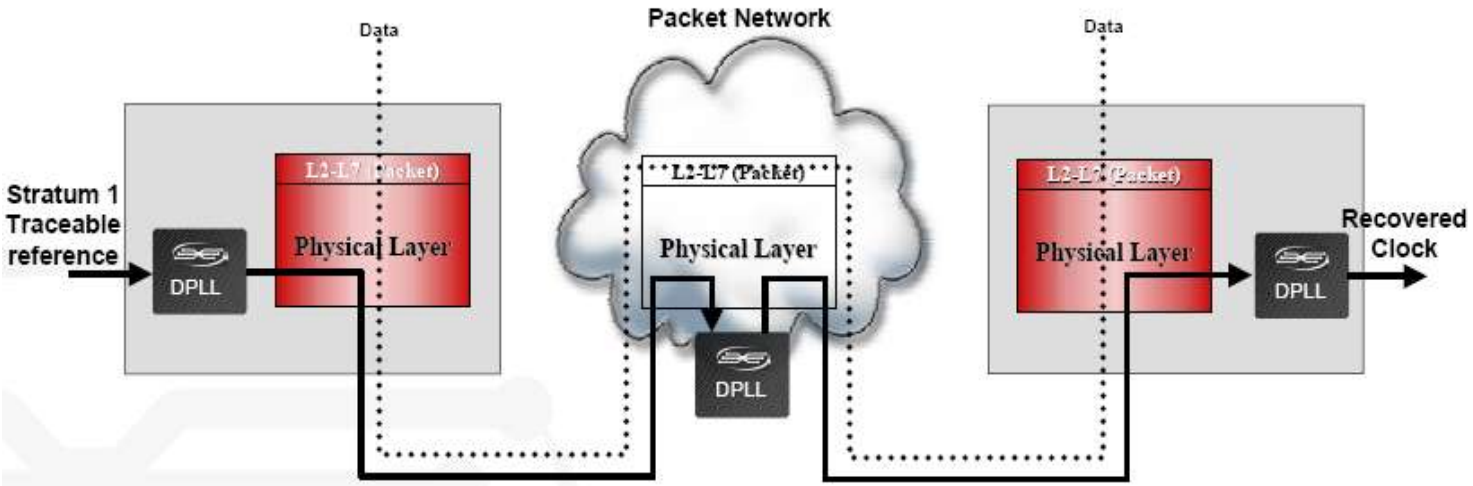
Frequency Sync – Sync Ethernet

Why Sync Ethernet

- Allows operators to converge services onto a single cost efficient network
- Provides a simple, reliable, well understood method of distributing synchronization over the physical layer through packet networks
- Based on a well established SONET/SDH synchronization distribution model

– Sync-E is layer 1 synchronization method

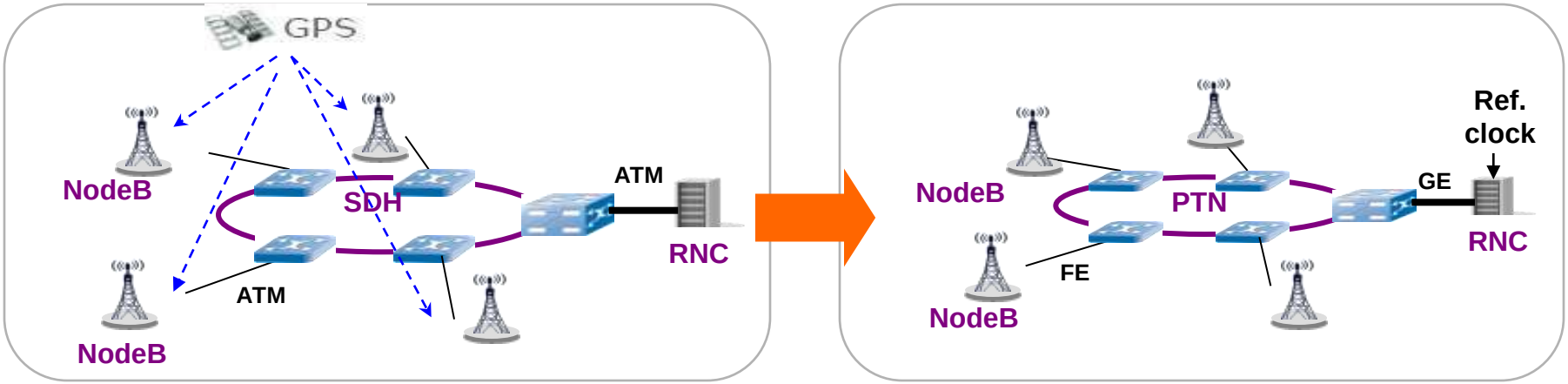
- Clock information will be send out when transmitting data with system clock in Physical layer.
- Recover line clock from received data in Physical Layer CDR and this clock is delivered to system DPLL processing unit as one of the system clock sources



- Uses the PHY clock

Time Sync Requirement and Solutions

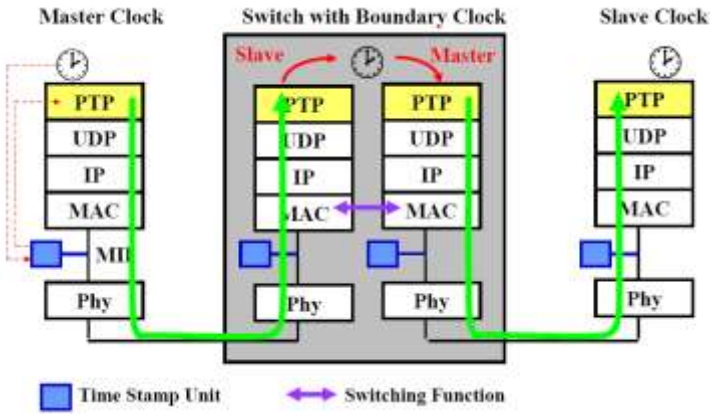
Used today		Use tomorrow	
GPS Used for CDMA and WiMAX	**TDM timing** Used for GSM and UMTS	**Atomic Clock (Rubidium)**	**IEEE1588/ PTP v2**
Accurate, precise, proven	Cost effective (free); proven for GSM and UMTS	Free-run, operates once installed	Cost effective; value add performance monitoring
Installation and maintenance requires effort	Economic drivers ushering in IP based backhaul; going away	Higher initial capital outlay; new technology; available	Network wide deployment needed; new technology
Not favored as a solution by operators (complexity and effort)	Will go away	Now economically viable	NEM's favorite: cheapest for BTS

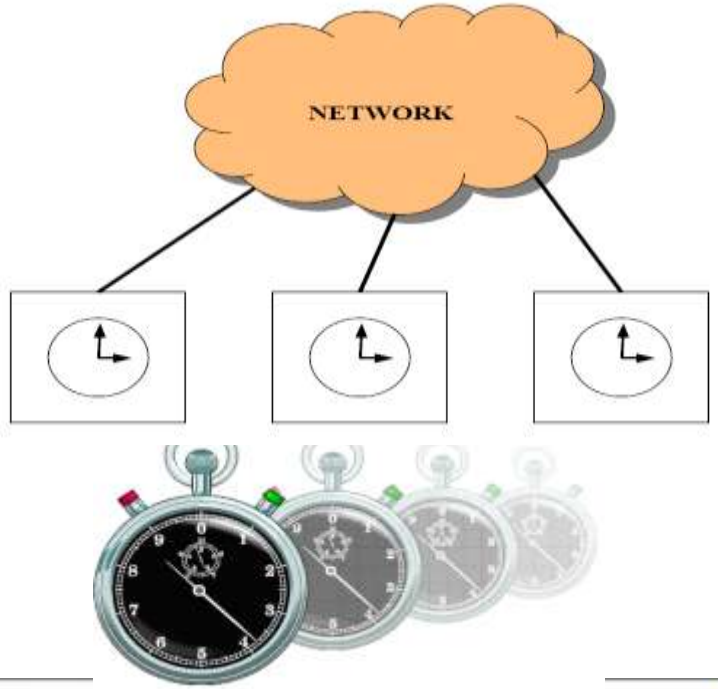


SNTP Simple Network Time Protocol (RFC 2030)
GPS Global Positioning System

Time Sync - IEEE 1588 v2

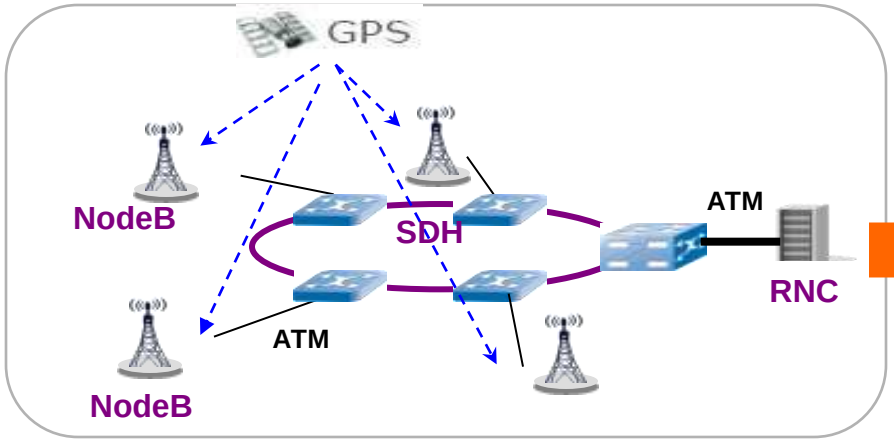
- **IEEE 1588v2 is a protocol designed to synchronize high quality real-time clocks in the nodes of a distributed system that communicate using a telecommunication network. Also Called PTP**
  - Syntonized Clock – Clock matched in phase and frequency, but no offset time of day
  - Synchronized Clock – Clock matched in phase, frequency, and offset (match time of day)
- **Support time Sync by Sync Etherne and 1588v2**
- **Distribute clock and time sync through PTN network with Sync Ethernet and 1588v2 supporting**



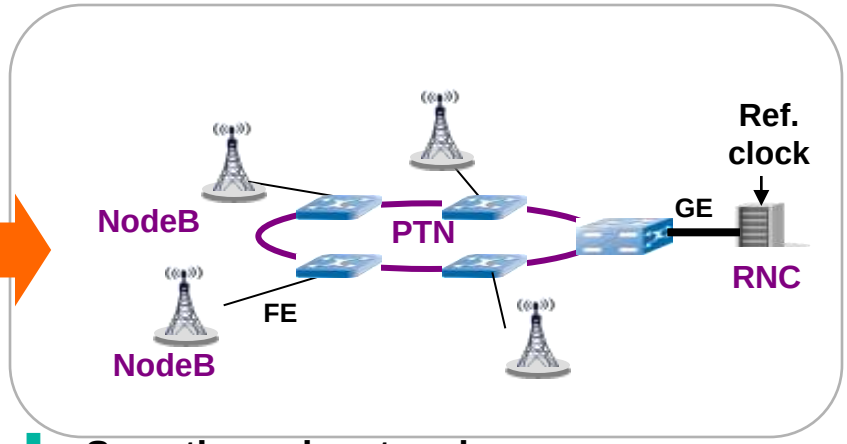


Time Sync Migration of Mobile Backhaul

Current mobile Networks :
Sync Through GPS



Future Mobile Networks :
Sync Through Network



Sync Through GPS

- For base stations, reference clock is distributed via GPS.
  - Time sync between NodeB and GPS: +/- 1.5us
- High cost and maintenance fee
- No Network management
- No protection which bring high fail ratio to base station
- Not easy to install GPS antenna for in-house base station

Sync through network

- Network Synchronization over packet networks
  - Sync Ethernet
  - IEEE 1588v2 (Time over Packet)
- Provide Time sync between BTS and external reference clock: +/- 1.5us
- Provide network management for clock and time sync
- Provide protection
- Provide sync together with transmission equipment.

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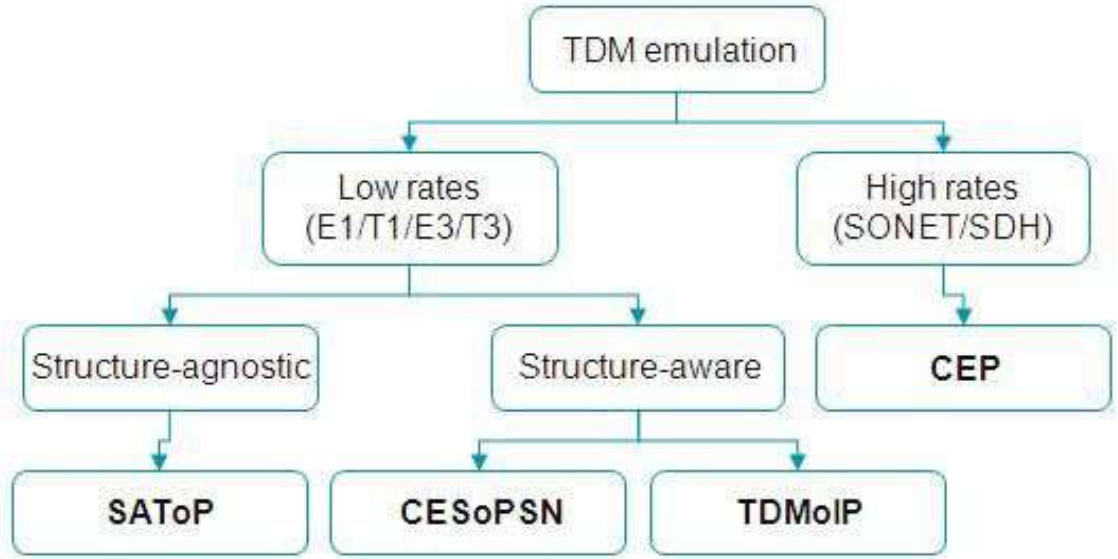
TDM Emulation Standards Summary



IETF

- **SATop** (Structure-Agnostic Time Division Multiplexing (TDM) over Packet) : RFC 4553
- **TDMoIP** (Time Division Multiplexing over IP): RFC 5087
- **CESoPSN** (Structure-Aware Time Division Multiplexed (TDM) Circuit Emulation Service over Packet Switched Network): RFC5086
- **CEP** (Circuit Emulation over Packet): RFC4842

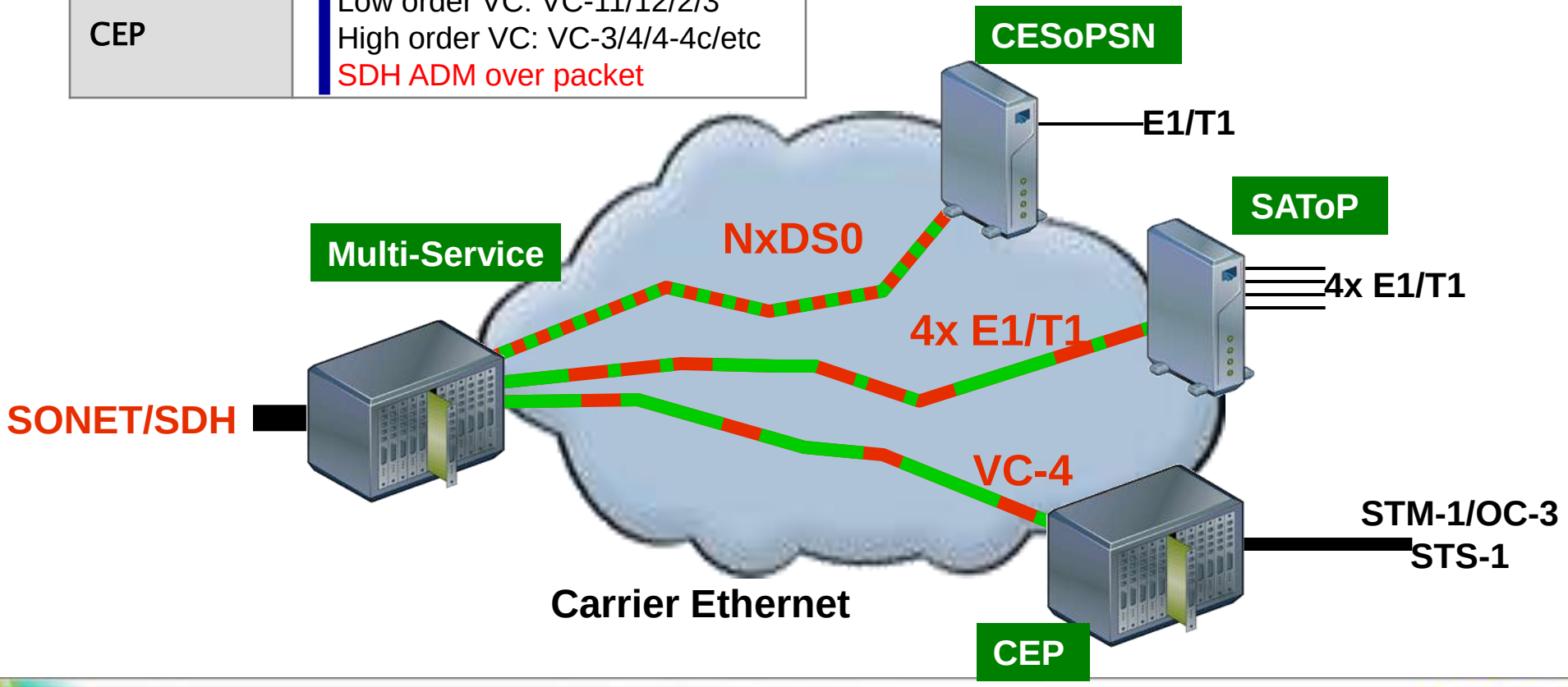
ITU

- Y.1431

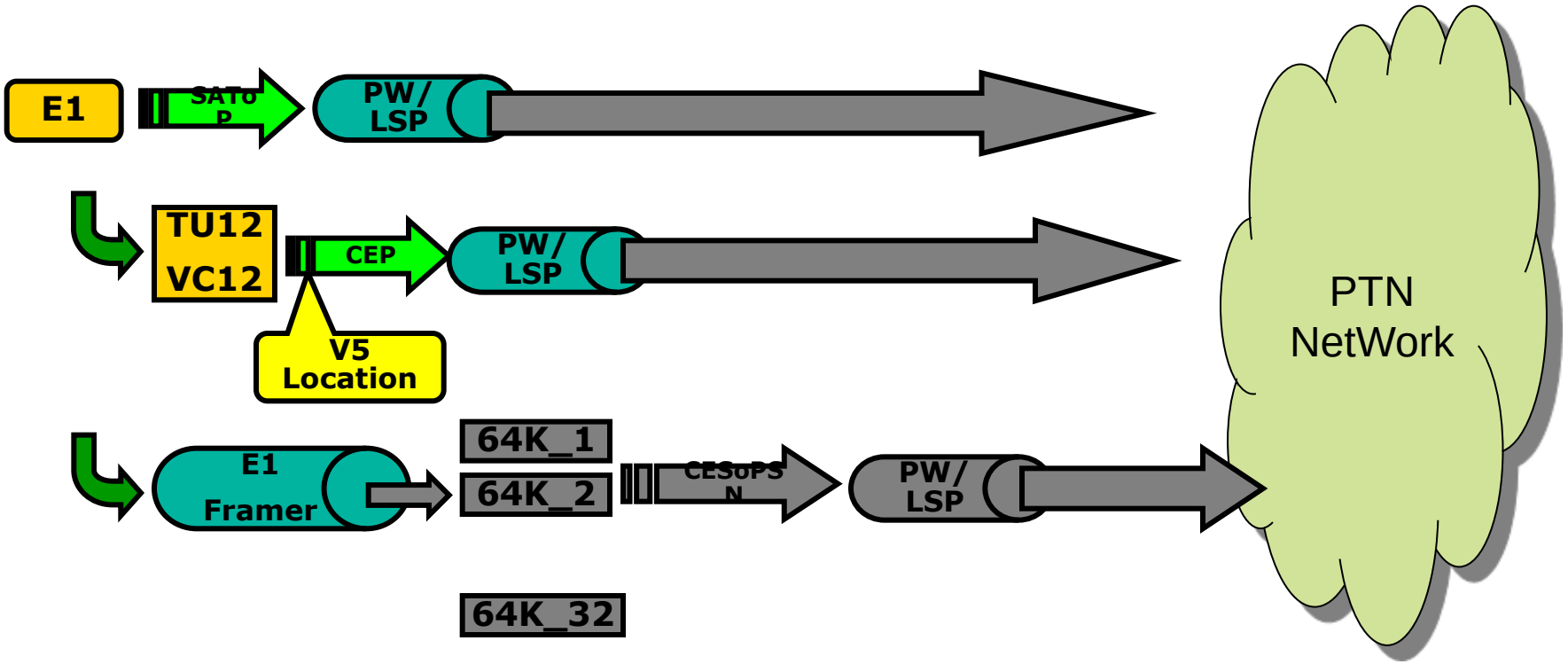
MEF and MPLS Forum

TDM Emulation over Packet Network

	Emulated Circuits
SAToP	T1/E1/T3 Clock & any data transport
CESoPSN	NxDS0 with or without CAS Efficient fractional/aggregate NxDS0
CEP	Low order VC: VC-11/12/2/3 High order VC: VC-3/4/4-4c/etc SDH ADM over packet

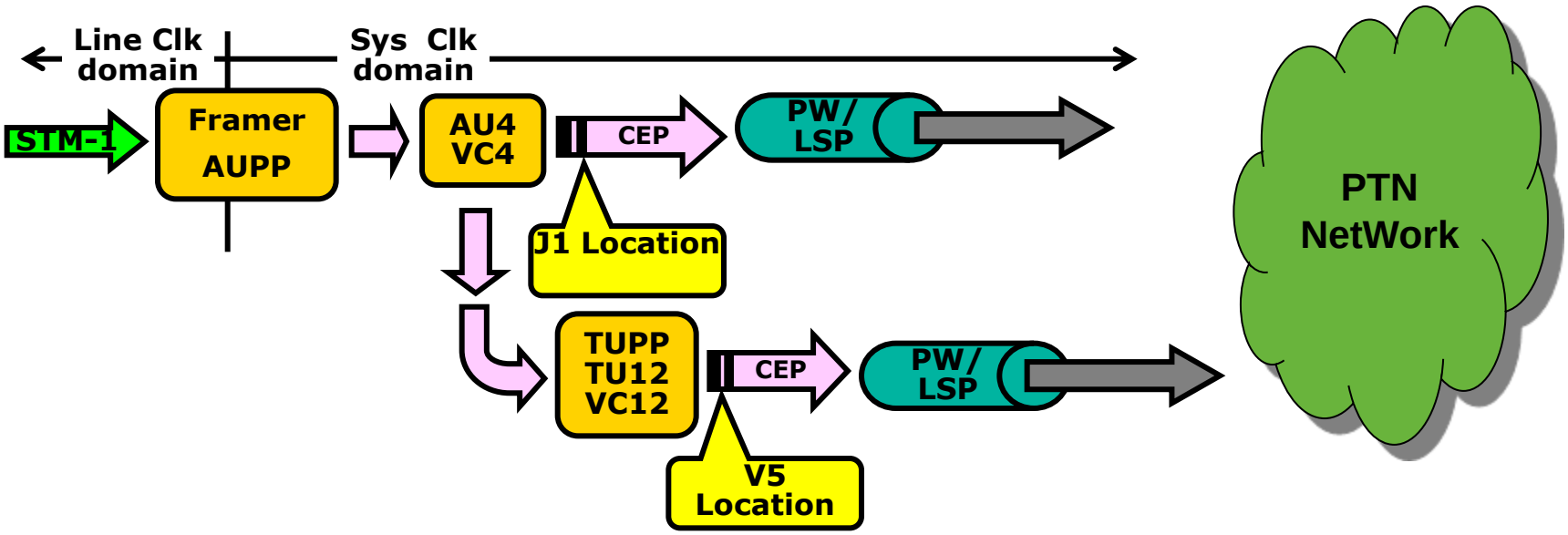


E1/T1 Emulation in PTN Network



	SATOP (RFC 4553)	CEP (RFC 4842)	CESoPSN (RFC 5086)
Band Width	E1/T1/E3/DS3	VC12/3/4	NxDS0
Application	P2P	P2P,Aggregation	P2P,Aggregation
Label resources	PW per link(E1/T1/E3/DS3)	Can be aggregated to VC4 PW	PW per link (Nx DS0)
Connection	Break the VC12 path	E2E VC12 OAM	E2E NxDS0
Clock	ACR	Sync/DCR	ACR

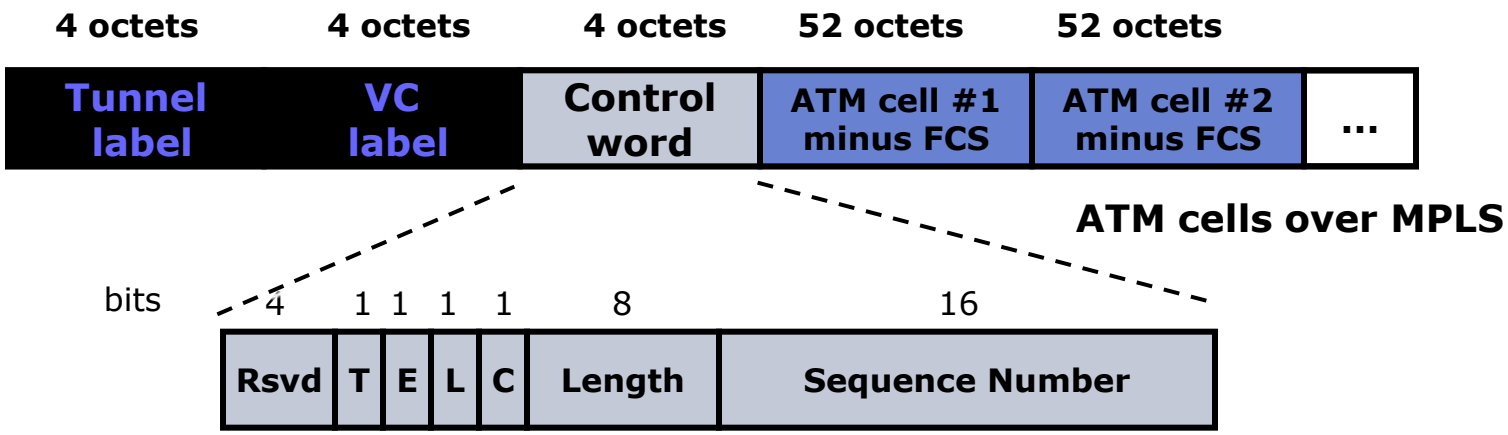
STM-1 Emulation in TN Network



	SDH/SONET	CEP
Container	VC-12/3/4	VC-12/3/4
Application	P2P, Aggregation	P2P,Aggregation
Data Plane	Time slot, TDM cross connect	PW/LSP, packet forwarding
Connection	E2E VC12/3/4 path/OAM	E2E VC12/3/4 path/OAM
Clock	Sync	SyNC/DCR

ATM Emulation: ATM over MPLS

- Fully in accordance with RFC 4717
  - the former draft-ietf-pwe3-atm-encap. It has been Published at 2006/12.
- Cell Relay mode:
  - ATM interface receives cells and transports them across the MPLS network. Cell relay with cell packing is used to send multiple cells in one MPLS frame, improving the efficiency of cell transport.
- ATM N to One Cell Encapsulation：
  - All AAL types are supported
  - ATM VPI/VCI is always there
  - One VCC/One PW, or Multiple VCC/One PW
  - Port, VPC or VCC based Cell concatenation Negotiation on the maximum number of Cell concatenation



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