PTN (Packet Transport Network) Interoperability Test——ITU-T G.8113.1 OAM

Part I

ITU-T packet transport network technology and OAM mechanism overview

Course Objectives:

Upon completion of this course, you will be able to:

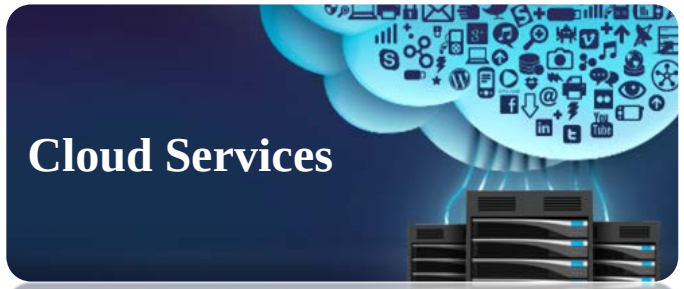
- Know the technical development, applications and progress of PTN in China
- Apply OAM mechanism in Packet Transport Network
- Understand the basic features and functions of ITU-T Y.1731 (Ethernet OAM) and G.8113.1(MPLS-TP OAM for PTN)
- Learn the test methodologies for ITU-T G.8113.1 C&I

Agenda

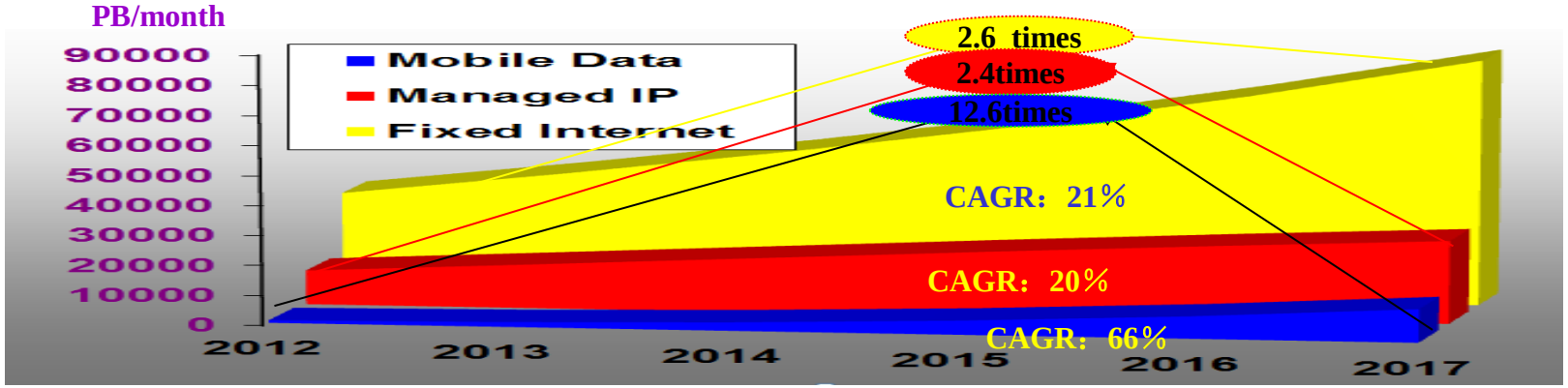
- **Services Driven Evolution to Packet Transport Network**
- **Why Packet Networks Need the OAM Mechanism?**
- **Introduction of ITU-T G.8013/Y.1731 and G.8113.1**
- **PTN Standardization and Deployment Progress in China**

Network evolution is driven by services

New Services & Applications



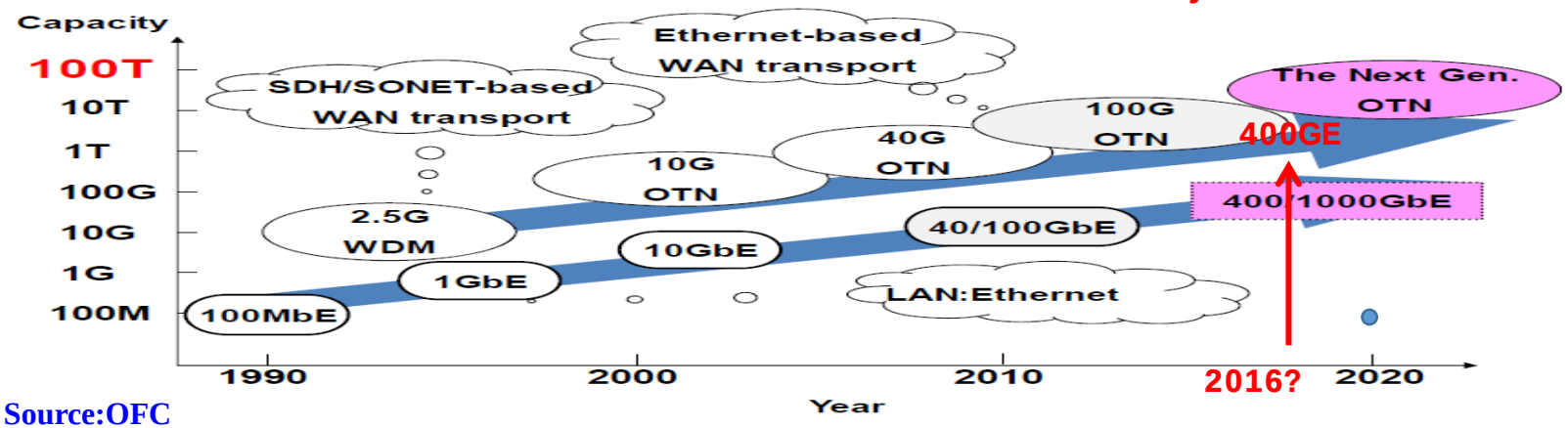
Internet of Things
Intelligent City
Intelligent Home Network



Future IP Data bandwidth forecast

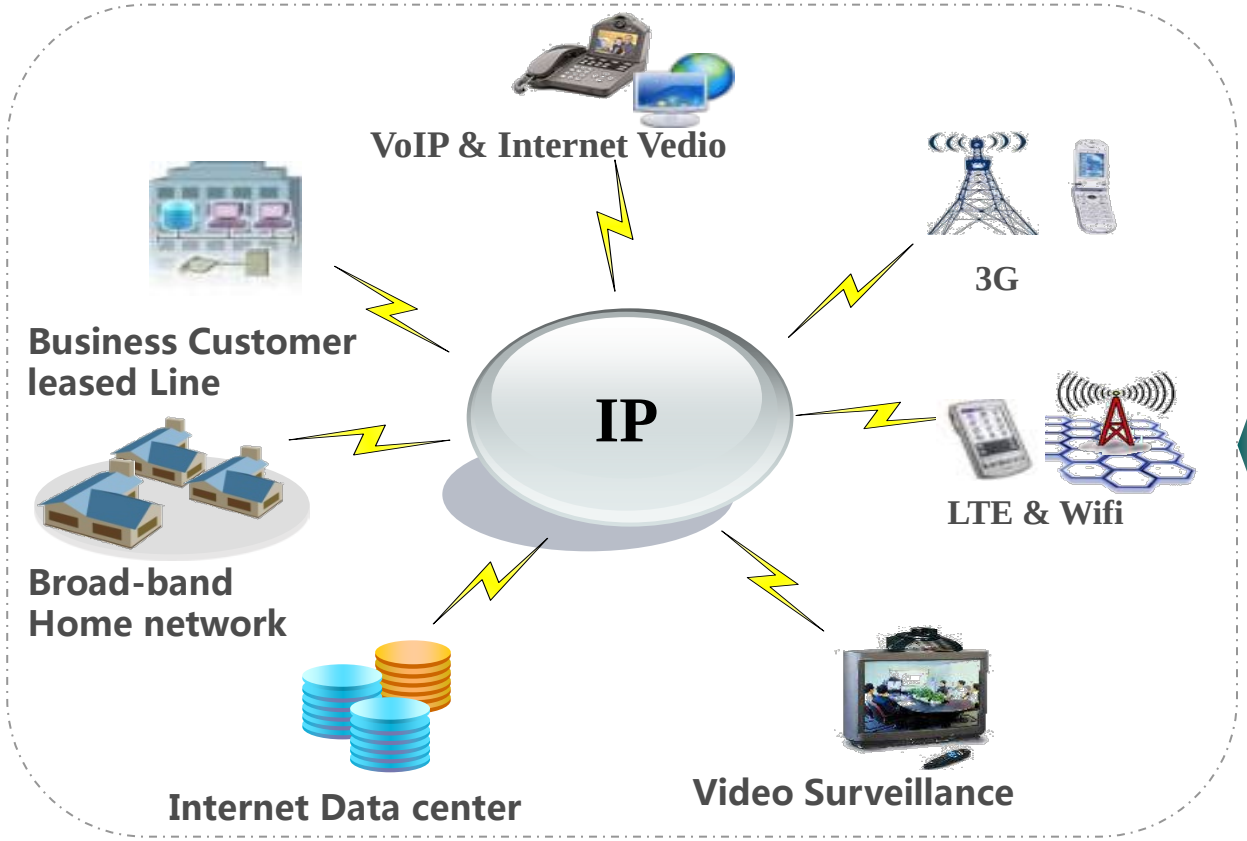
Source: CISCO VNI 2013

Evolution of Transport Technology



Source:OFC

All services transformed to IP-based



Traditional Services transformed to IP-based or vanished gradually.

- PSTN to Soft-switch or IMS;
- TDM Voice changed to VoIP
- GSM is vanished gradually.
- TDM N*64K and E1 leased line decreased dramatically

New Services are born as IP-based.

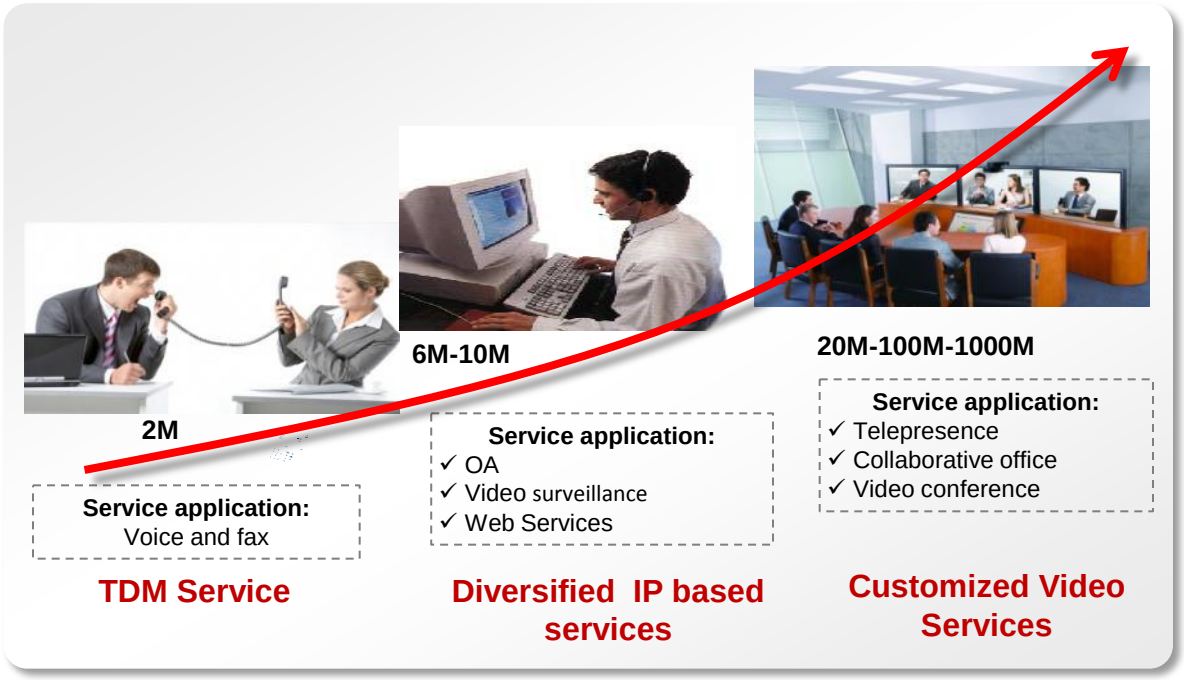
- Since 3GPP R7, packet domain was introduced.
- LTE EPC are all IP based.
- All kind of video services are IP-based or internet video.
- Ethernet L2VPN Services are booming.

Advantages of IP-based services trend

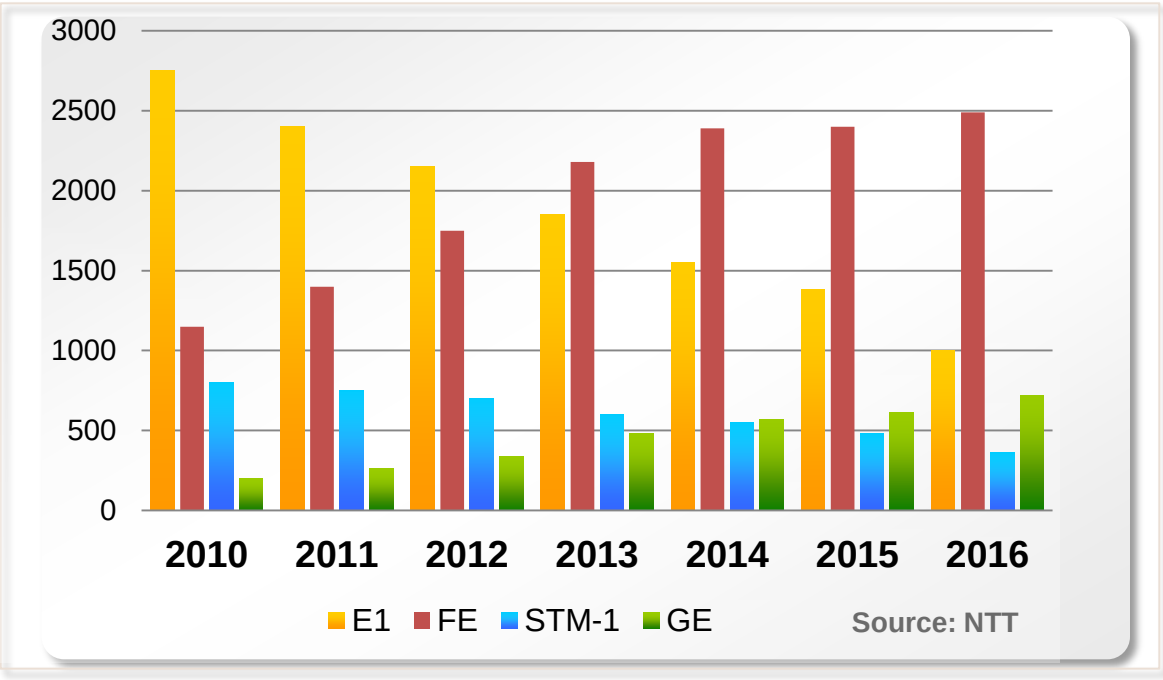
- Keep network protocol simple
- Reduce CAPEX and OPEX
- Easy to provide converged multi-services .

Global IP Trend Progress Challenged Operators' Existing Network

IP service dominated in the Network Traffic



Cloud computing and big data driving all-around speedup



Bandwidth & QoS

Interfaces: TDM to Ethernet & IP

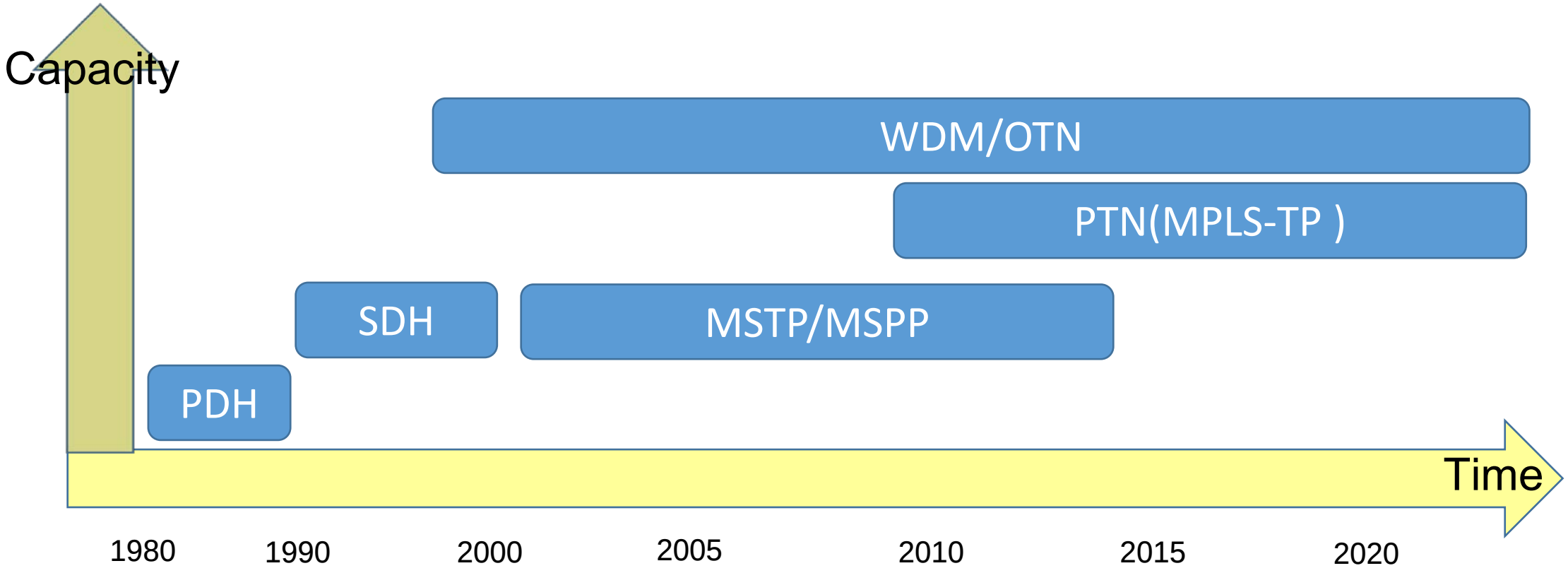
Optical Network is the foundation for Information Society

Optical network is

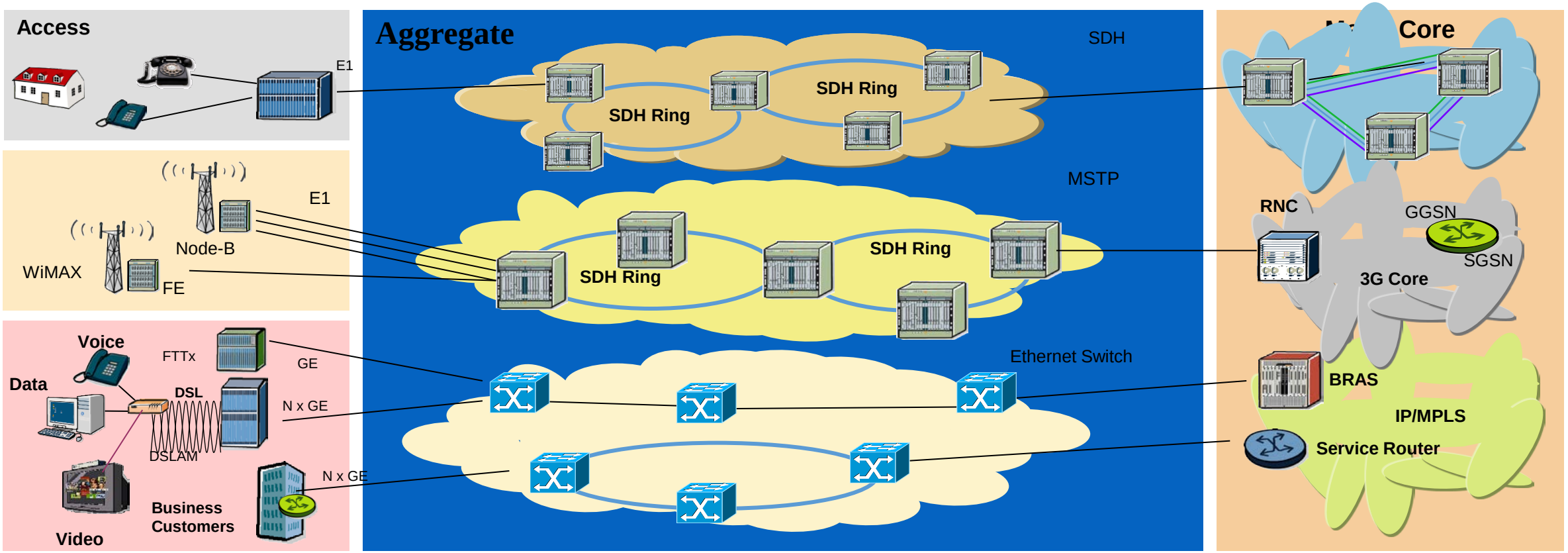
30% of network CAPEX

- the high speed highway to promote the development of information consumption.
- the best technical solution to realize high-speed broadband access network
- the mobile backhaul network supporting the development of mobile Internet

The Technical Development History of Optical Network

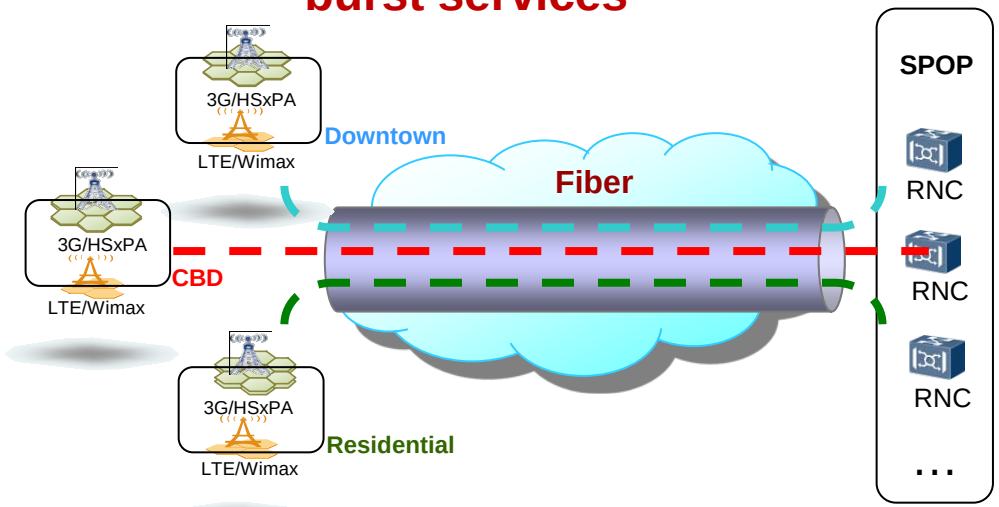


Chinese Operators' Metro Optical Transport Network in 2008's

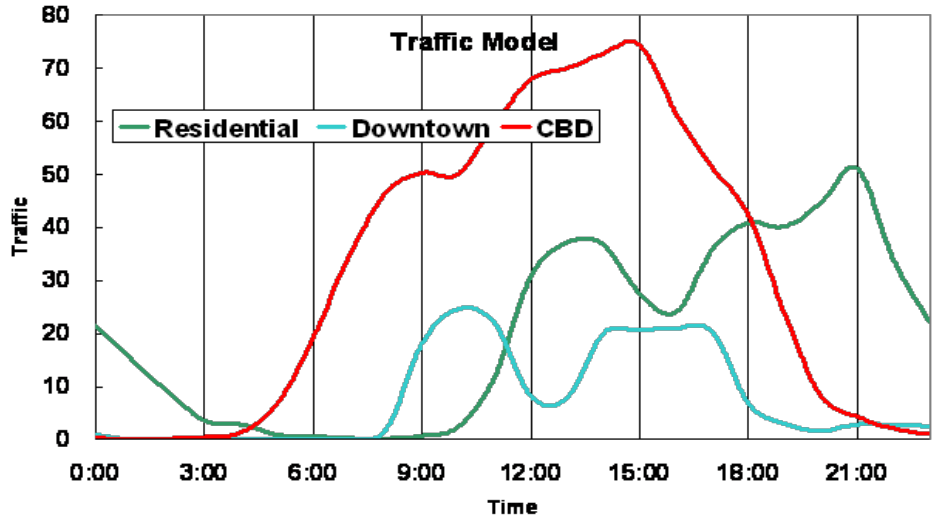


Limitations of SDH/MSTP in Packet Era

SDH hard pipe for burst services

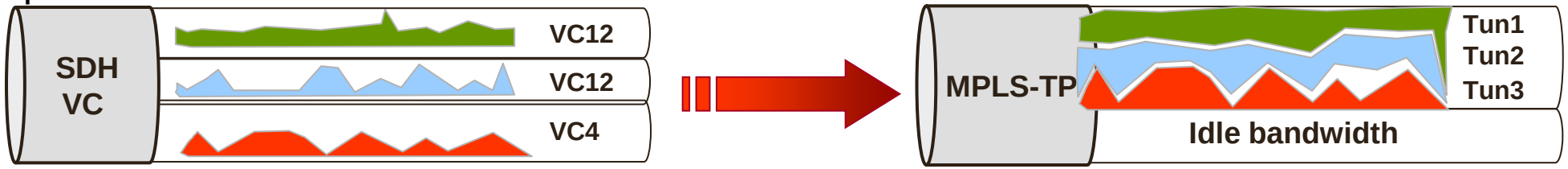


Packet service flow model



Only hard pipes, with low bandwidth efficiency for unexpected services

Soft pipe, idle bandwidth sharing and statistics reuse



- The VC pipes of SDH/MSTP use exclusive bandwidth, and the bandwidth efficiency is low during packet service bearer.
- The SDH bandwidth scalability is poor and network adjustment is not flexible in the event of obvious data service speedup.

Two Evolution way for Packet Network

Ethernet based

Multicast

RSTP、MSTP

RPR、ERP

Q-In-Q/VLAN-XC

MAC-in-MAC（PBB）

PBB-TE

IP/MPLS based

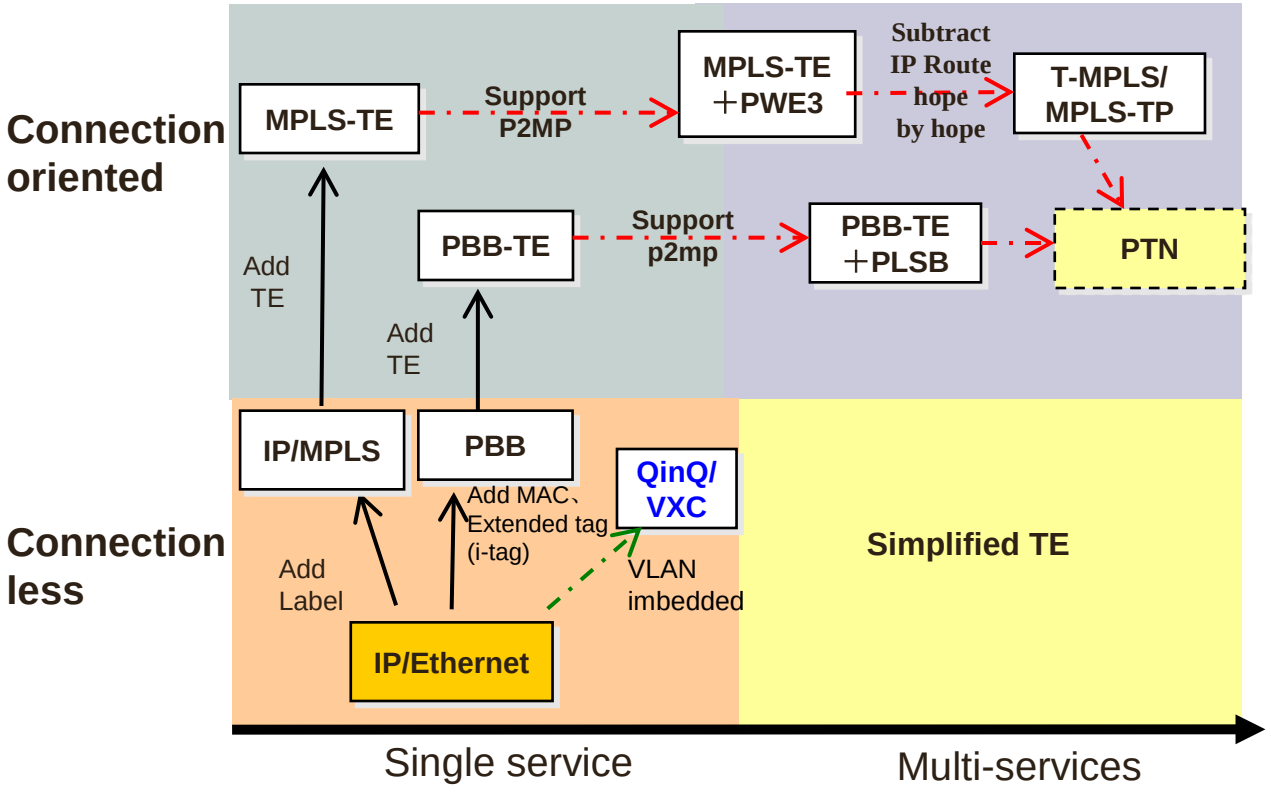
IP+MPLS

PW

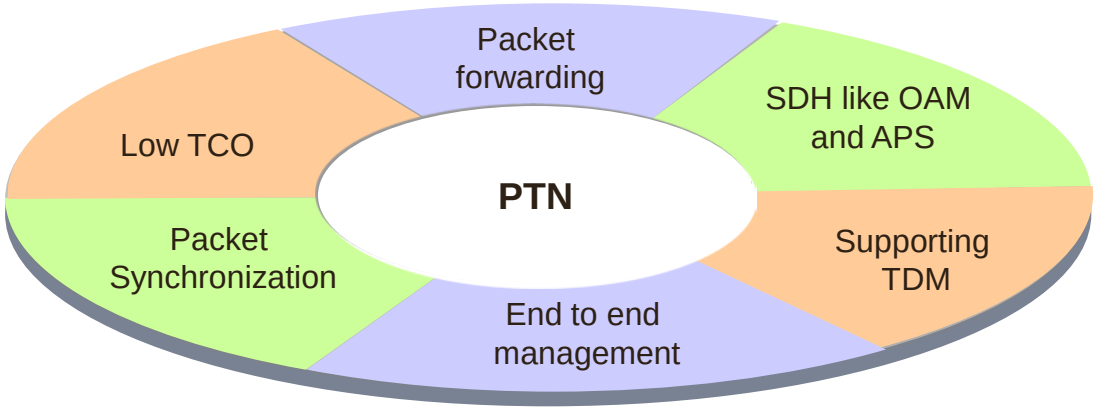
VPLS/H-VPLS

T-MPLS/MPLS-TP

PTN Technical Evolution



Transport & Data Converged Technology

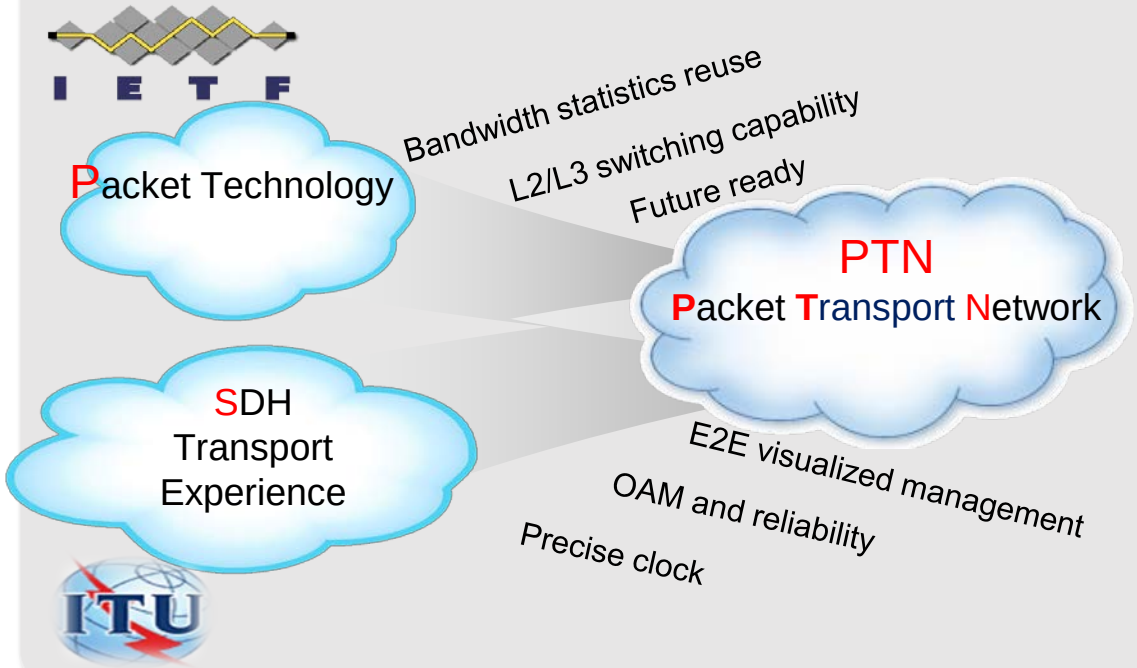


PTN is a blend of grouping of Ethernet and IP/MPLS technology advantage, improve connectionless, the shortcomings of the OAM, protection and network management is weak.

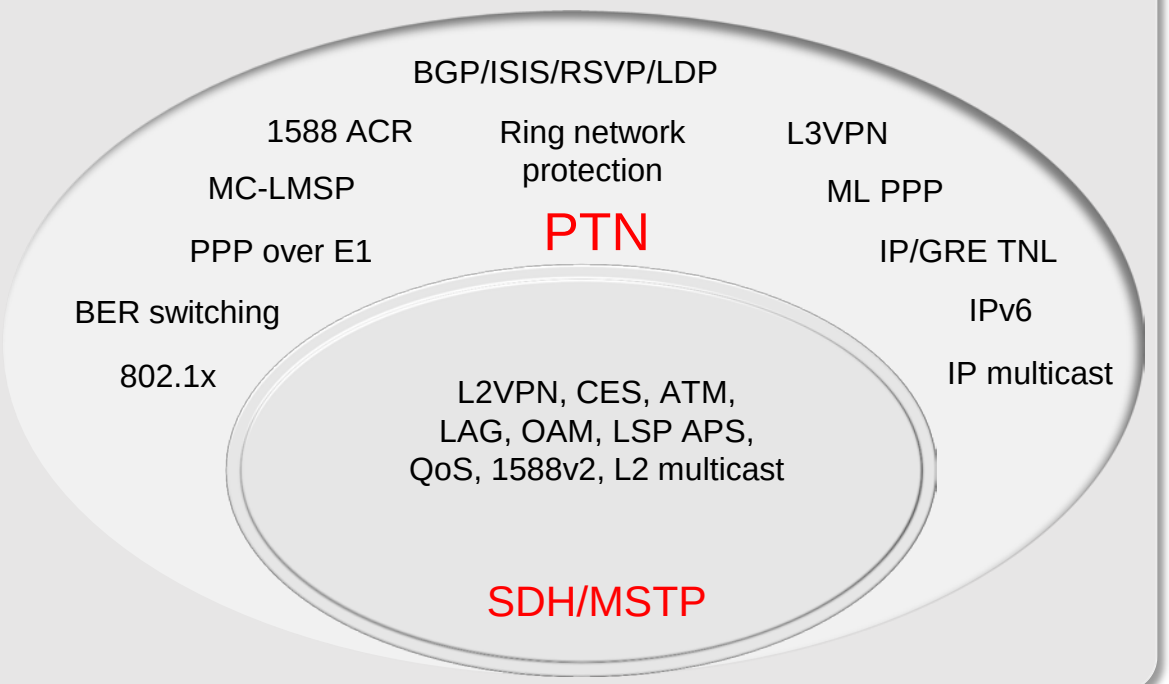
- PTN is emerging, based on the grouping, connection-oriented uniform transmission technology, the IP/MPLS technology simplified (IP by jumped forward, the last pop-up, equivalent multipath, etc.) and improvement (OAM, protection and network management.

PTN Inherited Many SDH Advantages While Evolving to the Packet Era

MPLS-TP packet transport solution



Compatible with SDH, extensive packet transport solution



PTN-based transport network encompasses various features to meet diversified complex scenarios and well adapt to the evolution.

PTN Leading Transport Network to the Packet Era

Transport network evolution: PDH->SDH->MSTP->PTN+OTN->Future POTN

MPLS-TP (PTN) = IP/MPLS − Connectionless & Dynamic + OAM & Protection

	MPLS Feature	SDH Feature
Data plane	➢ Label switching ➢ QoS assurance	➢ VC bearer ➢ Enhanced OAM ➢ Enhanced protection
Control plane	➢ LSP: GMPLS (RSVP-TE), PW: LDP	➢ Centralized control
Management plane	Separation from control plane	➢ E2E visualized management

Agenda

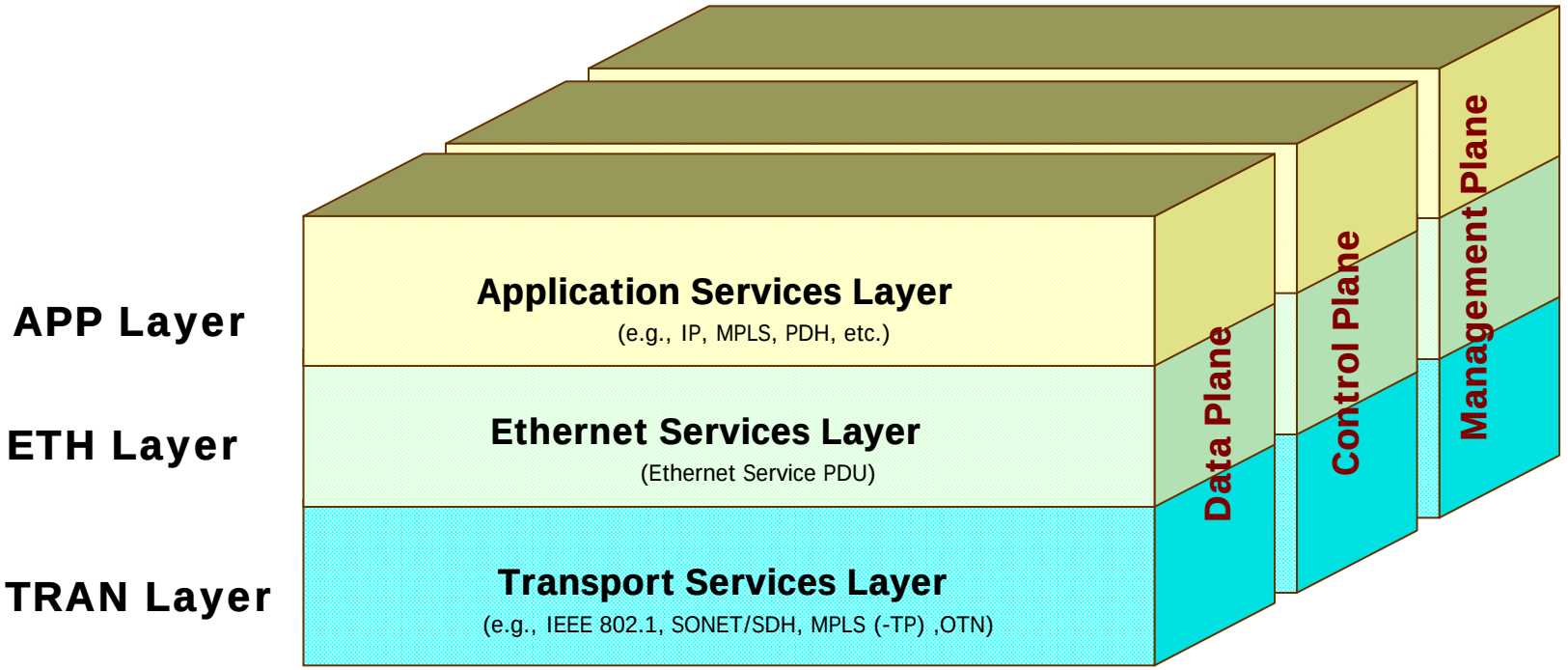
Services Driven Evolution to Packet Transport Network

Why Packet Networks Need the OAM Mechanism?

Introduction of ITU-T G.8013/Y.1731 and G.8113.1

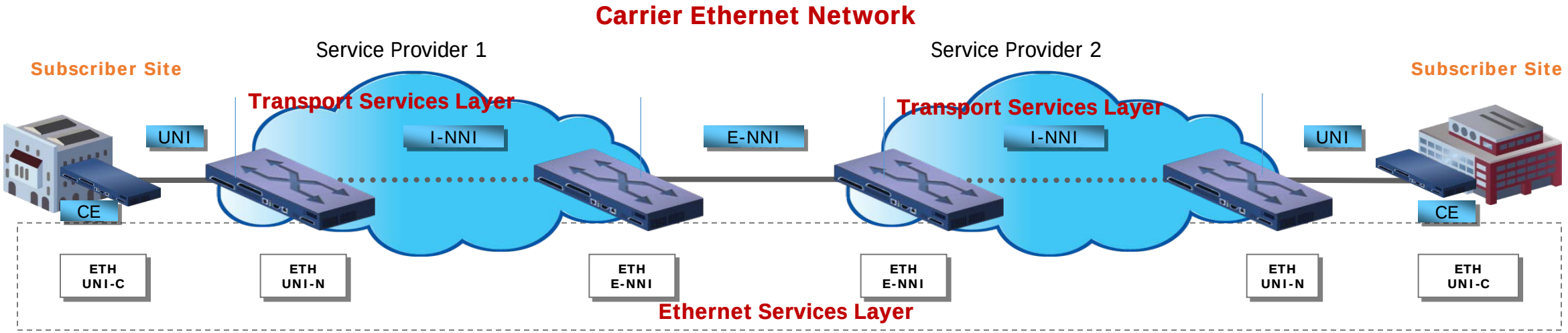
PTN Standardization and Deployment Progress in China

Carrier Ethernet Architecture



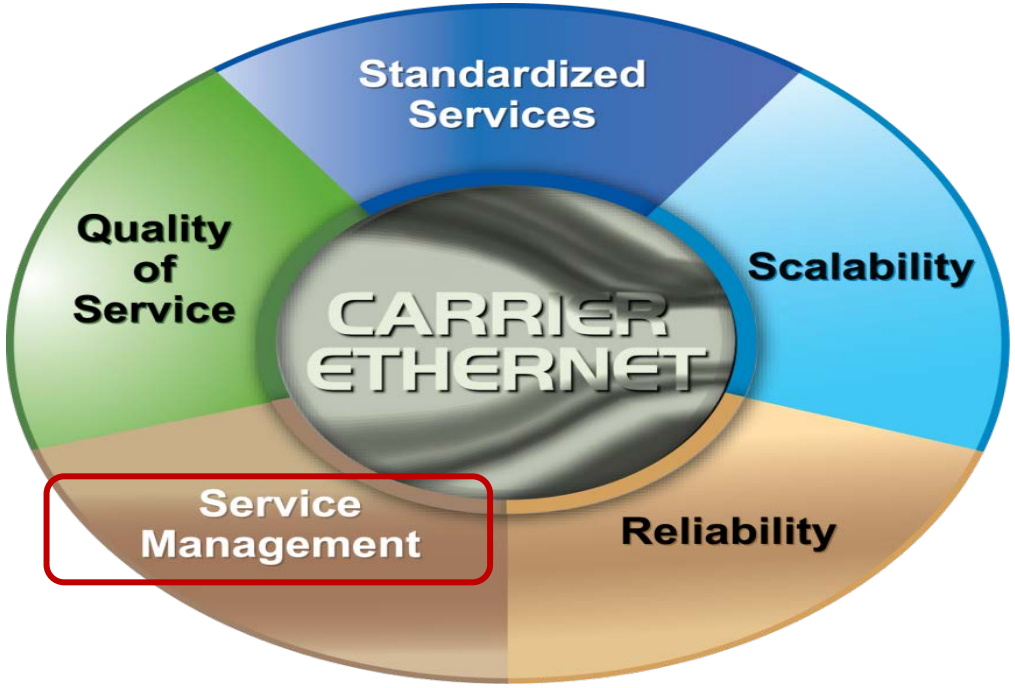
The MEF has defined Carrier Ethernet as: A ubiquitous, standardized, carrier-class Service

Source: MEF



Carrier Ethernet Services require Carrier grade OAM

MEF: Five Attributes for Carrier Ethernet



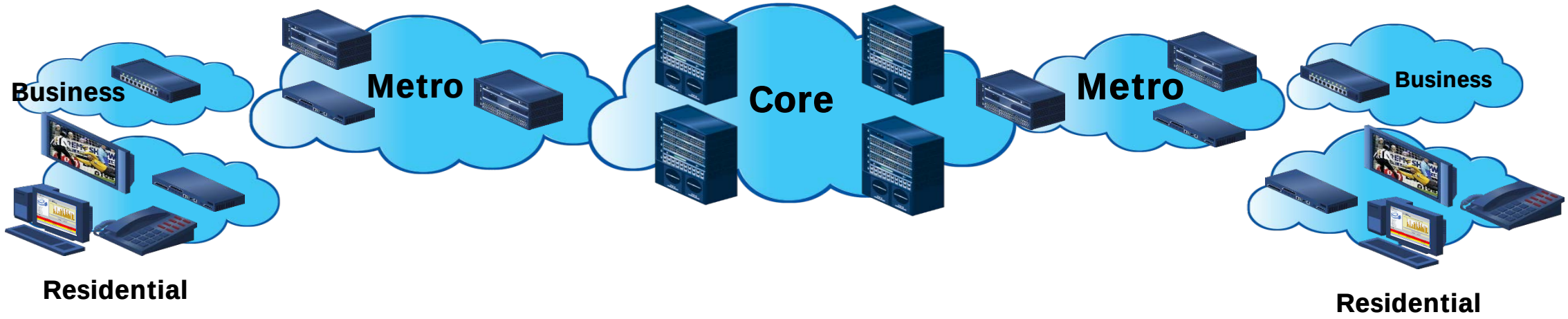
- **Carrier Ethernet services are carried over physical Ethernet networks and other transport technologies.**
- **The ability to monitor, diagnose and centrally manage the network, using standards-based vendor independent implementations: Carrier-class OAM**

Service Management : Fault and Performance Management in service level.

OAM = Operation + Administration + Maintenance

SDH and OTN network has strictly defined OAM mechanisms.
Ethernet and IP network are extended to support OAM.

Carrier Ethernet Network Architecture



Access:

- PDH
- Active fibre
- PON
- HFC
- Wireless
- **CE UNI must be Ethernet**

Metro:

- SDH/SONET
- 802.1ad Q-in-Q
- PBB/PBB-TE (PBT)
- IP/MPLS
- MPLS-TP
- T-MPLS

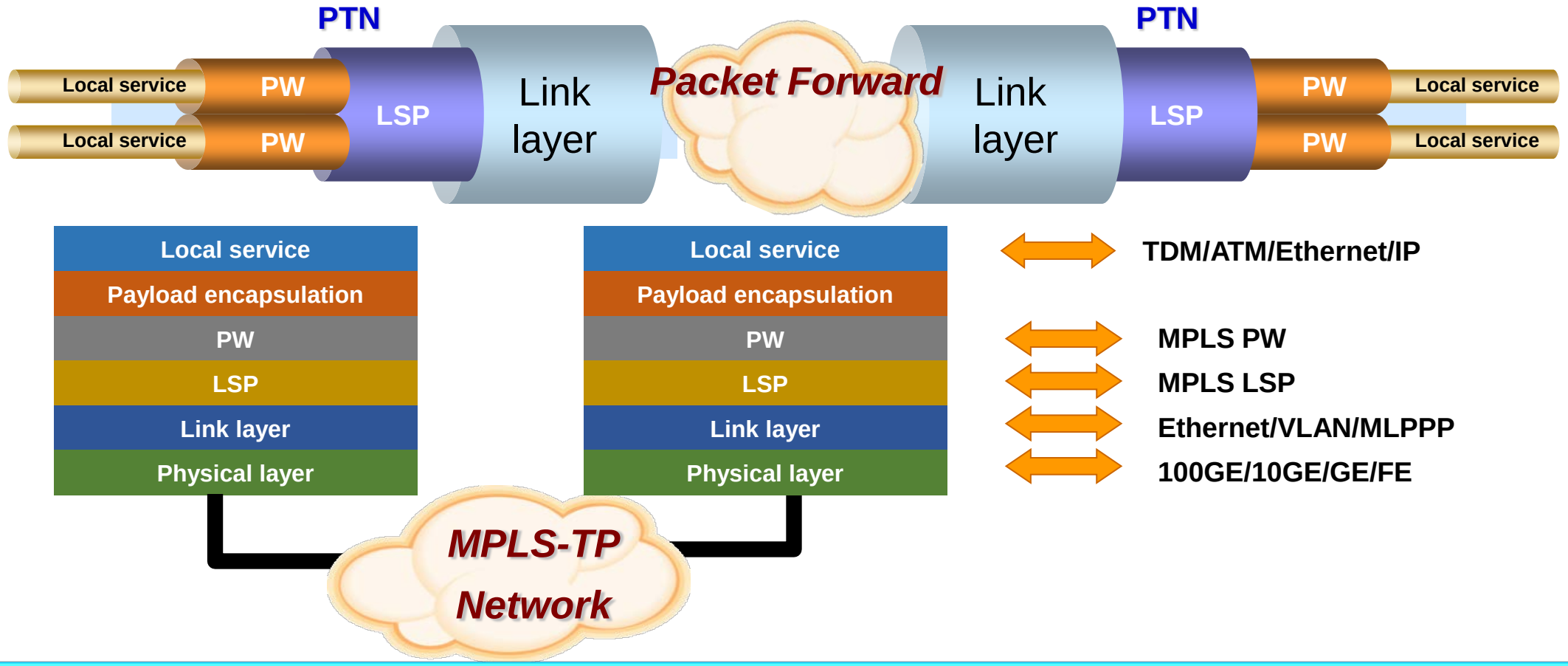
Core:

- Primarily IP/MPLS
- SDH/SONET
- WDM/OTN

Service Management:

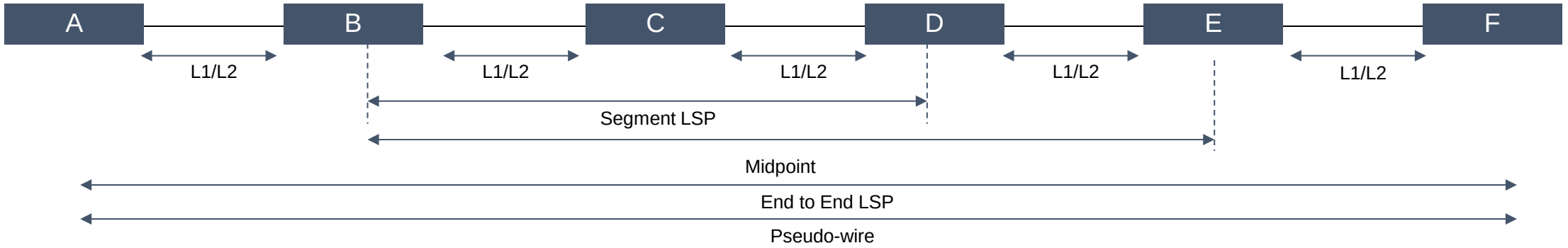
- Ethernet OAM/CFM
- IP/MPLS OAM
- Transport network OAM
- End-to-end requires inter-working

General View of Packet Network based on MPLS(-TP)



Packet Network is based on packet frame forwarding, without SDH like TDM Frame structure with in-band overheads which performs fault detection, fault indication and performance monitoring functions. So OAM mechanism is important for Packet network to implement service and network management.

OAM hierarchy and mechanisms



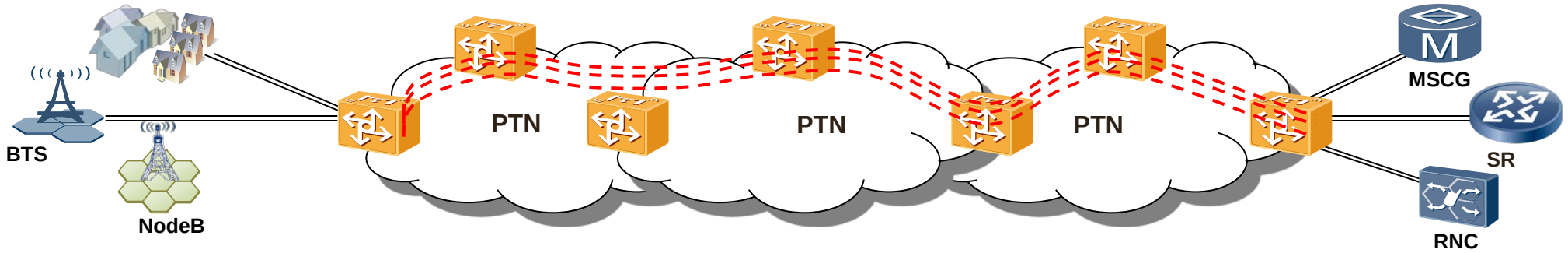
- **L0/L1 : Loss of Light; G.709, SONET/SDH LoS, LoF, ES**

- **Non MPLS L2 connectivity : Native L2 solution 802.1ag , Non IP BFD**
  - **Failure propagation across layers is supported by this architecture**

- **General LSPs : Generic Exception Label and Generic Associated Channel**
  - **Includes End to End and segment LSPs**
  - **Used to carry a variety of OAM, Mgmt, signalling protocols.**

- **Pseudo-wires : PWE3 Associated Channel**

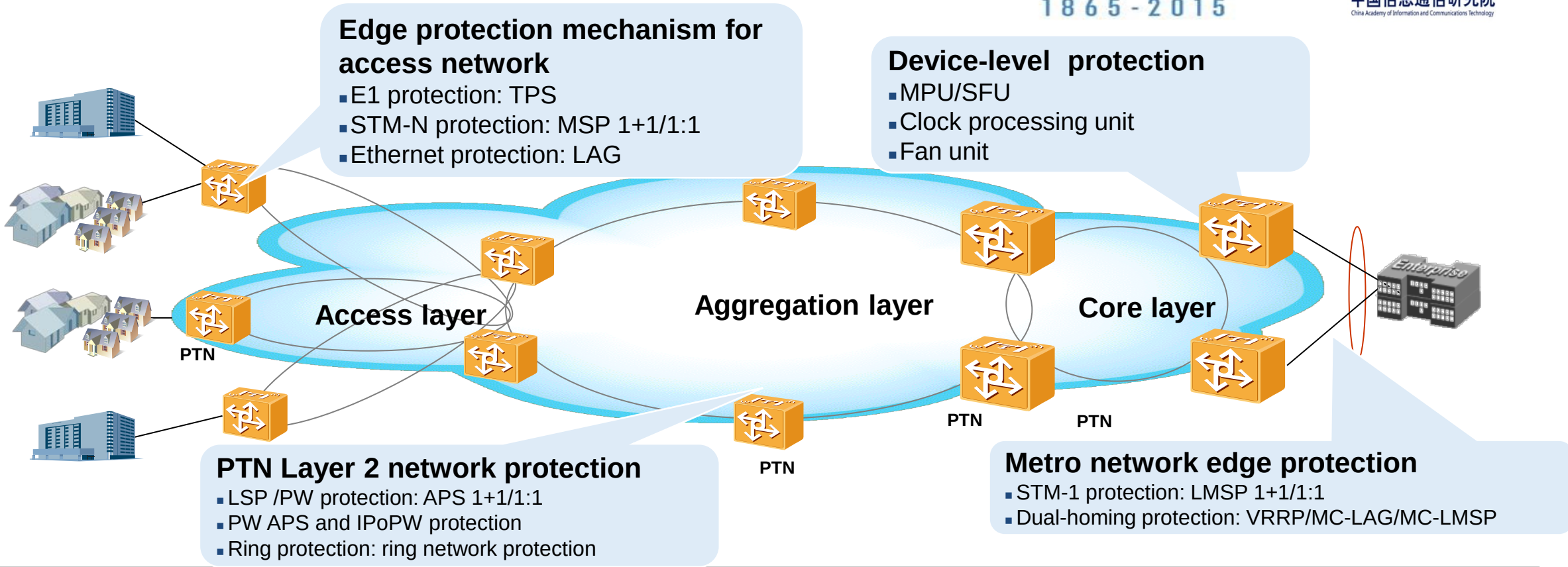
Hierarchical OAM Enhanced Fast Troubleshooting in PTN



PTN OAM provides hierarchical fault and performance maintenance capabilities just like SDH does.

- **Hierarchical fault and performance monitoring, achieving fast fault detection and troubleshooting**
- **Multi-layer detection, high reliability, delivering the same level of protection upon a fault**

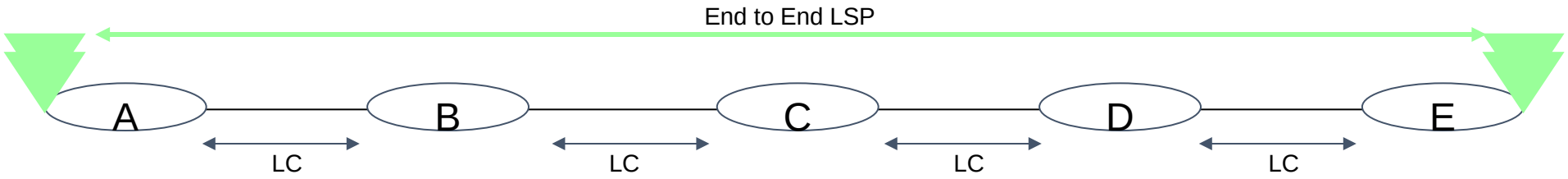
Fast and Reliable OAM supporting 50ms Protection



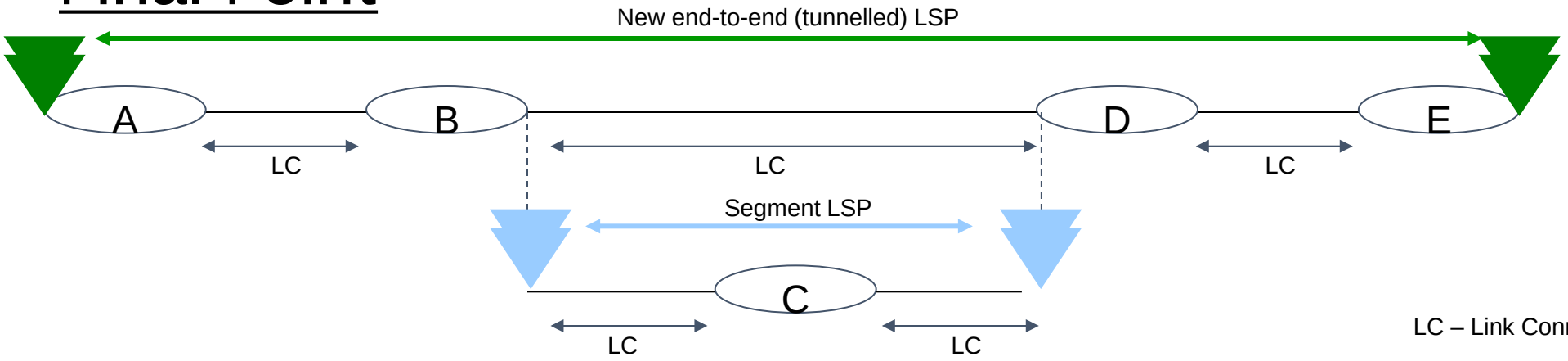
- **Fast troubleshooting:** ASIC is used to achieve OAM and fast detection within 3.3 ms, which ensures service protection switching for nodes and links within 50 ms.
- **Protection for all services:** OAM specifications match the number of services, ensuring that switching can be concurrently performed for all services.
- **All-around E2E service protection:** Various protection technologies are supported, ranging from access-layer to network-layer to core edge technologies.

Segment LSP setup

Starting Point

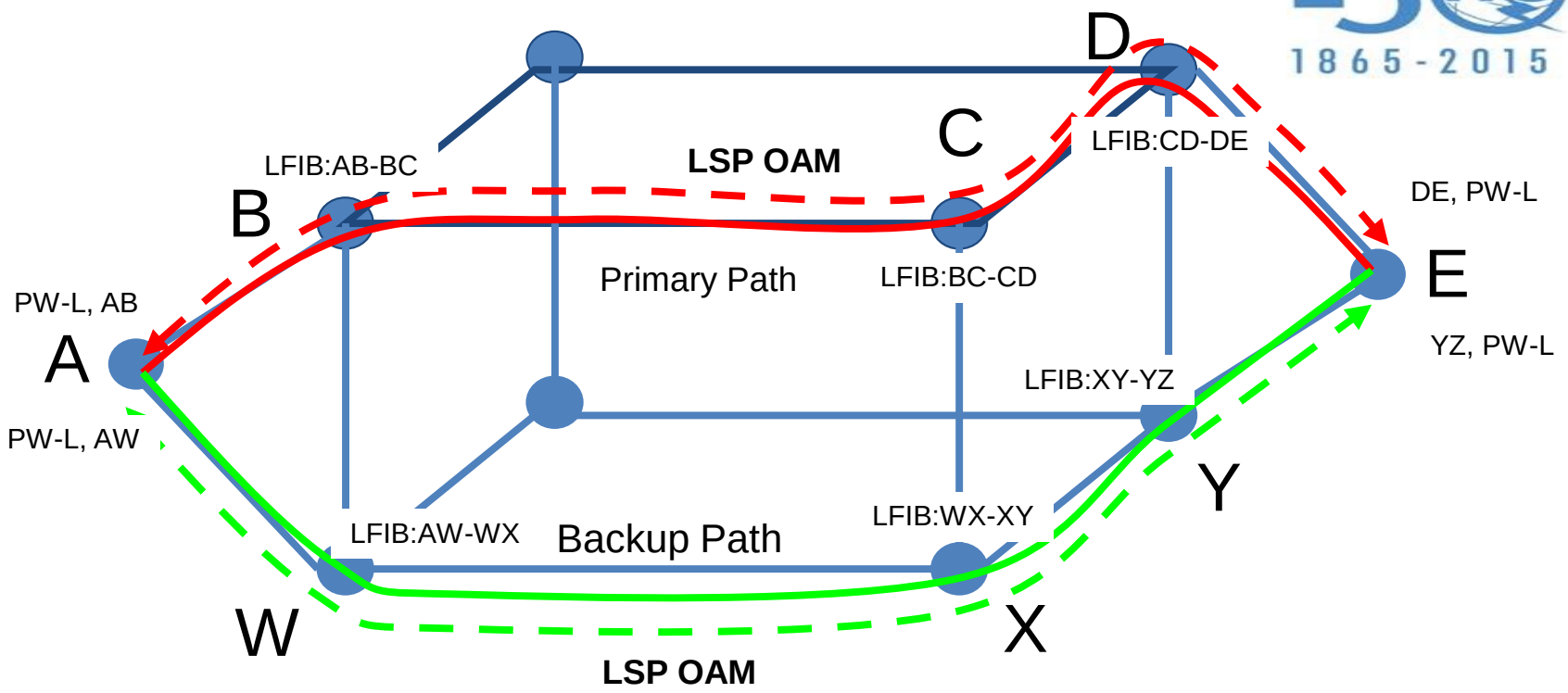


Final Point



LC – Link Connection

End to End LSP OAM operations



- Path diversity is not part of the OAM process. It is the responsibility of the Control Plane
- OAM function uses LFU with Generic Channel Association
- Pre-provisioned primary and backup paths
- LSP OAM running on primary and back-up paths
- OAM failure on backup path → Alert NMS
- OAM failure on primary path →A and E updating LFIB to send and receive PW-L traffic over backup path

Agenda

Services Driven Evolution to Packet Transport Network

Why Packet Networks Need the OAM Mechanism?

Introduction of ITU-T G.8013/Y.1731 and G.8113.1

PTN Standardization and Deployment Progress in China

ITU-T G.8113.1 MPLS-TP OAM Application and Function

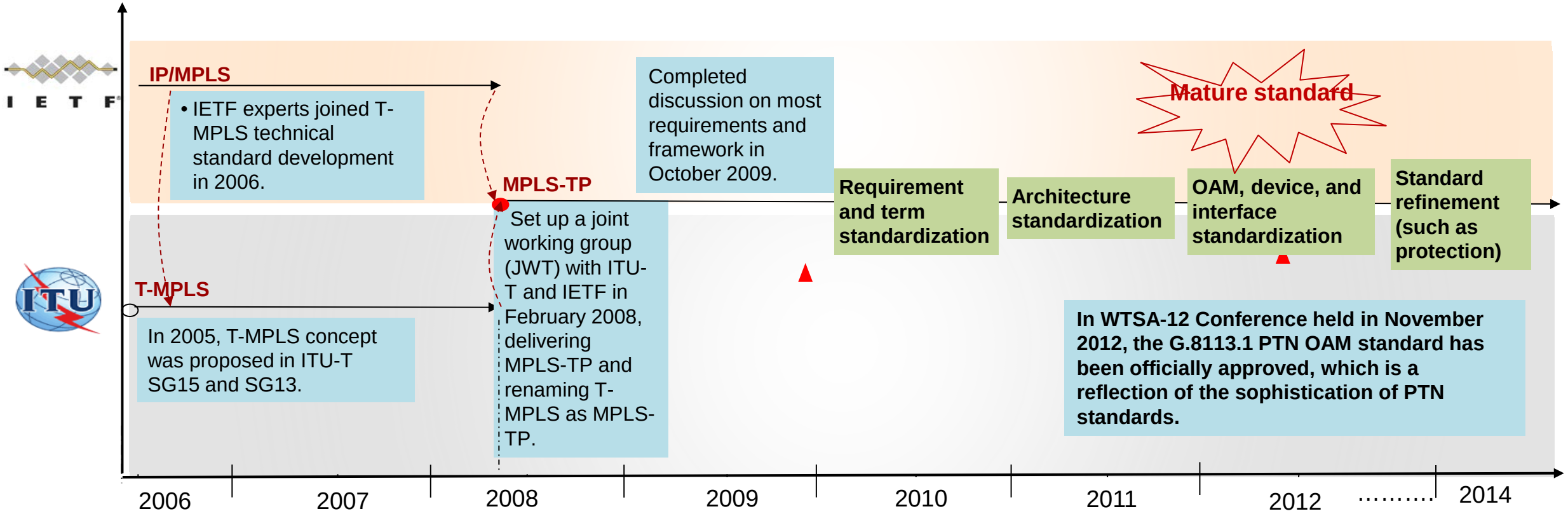
Application	OAM function	
Fault management	Pro-active	Continuity check and connectivity verification (CC/CV)
		Remote defect indication (RDI)
		Alarm indication signal (AIS)
		Client signal fail (CSF)
	On-demand	Connectivity verification (CV)
		Route tracing (RT)
		Diagnostic test (DT)
		Locked signal (LCK)
Performance management	Pro-active	Loss measurement (LM)
		Delay measurement (DM)
	On-demand	Loss measurement (LM)
		Delay measurement (DM)
Other applications	Automatic protection switching (APS)	
	Management communication channel/Signalling communication channel (MCC/SCC)	
	Vendor-specific (VS)	
	Experimental (EXP)	

Requirements for G.8113.1 and Y.1731 OAM Function in PTN

Type		Function	ITU-T G.8113.1			ITU-T Y1731
			Section Layer OAM	LSP Layer OAM	PW Layer OAM	ETH Service OAM
Proactive OAM	Fault Management	Continuity Check（CC）	Mandatory	Mandatory	Mandatory	Mandatory
		Remote Defect Indication（RDI）	Mandatory	Mandatory	Mandatory	Mandatory
		Alarm Indication Signal（FDI/AIS）	NA[1]	Mandatory	Mandatory	Mandatory
		Lock（LCK）	Optional	Optional	Optional	Optional
		Client Signal Failure（CSF）	NA	NA	Mandatory	Mandatory
	Performance Monitoring	Loss Measurement（LM）	Optional	Mandatory	Optional	Optional
Ondemand OAM	Fault Localization	Loopback（LB）	Mandatory	Mandatory	Mandatory	Mandatory
		Link Trace（ LT）	NA	Mandatory	Mandatory	Mandatory
		Lock（LCK）	Optional	Optional	Optional	Optional
		Tandem Connection Monitoring（TCM）	NA	Optional	Optional	Optional
	Performance Monitoring	Loss Measurement（LM）	Optional	Mandatory	Mandatory	Mandatory
		Delay Measurement（DM）	Optional	Mandatory	Mandatory	Mandatory
		Test（TST）	Optional	Optional	Optional	Optional
Others	APS		Mandatory	Mandatory	Optional	Optional
	MCC/SCC		Optional	NA[1]	NA[1]	NA[1]
	Vendor Specific		NA[1]	Optional	Optional	Optional
	Experiment Specific		NA[1]	Optional	Optional	Optional

Note：NA means not applicable。

Standardization History of MPLS-TP in ITU-T & IETF



- **MPLS-TP standards have become increasingly mature, which is a reflection of the coopetition of IETF and ITU-T as well as the integrated development of the transport and data industries.**
- **The standards drive industry development while serving industry members. MPLS-TP has been put into wide commercial use for mainstream vendors and carriers.**

MPLS-TP Standardization in ITU-T

ITU-T SG15

MPLS-TP network structure
MPLS-TP interface
MPLS-TP device function (universal)

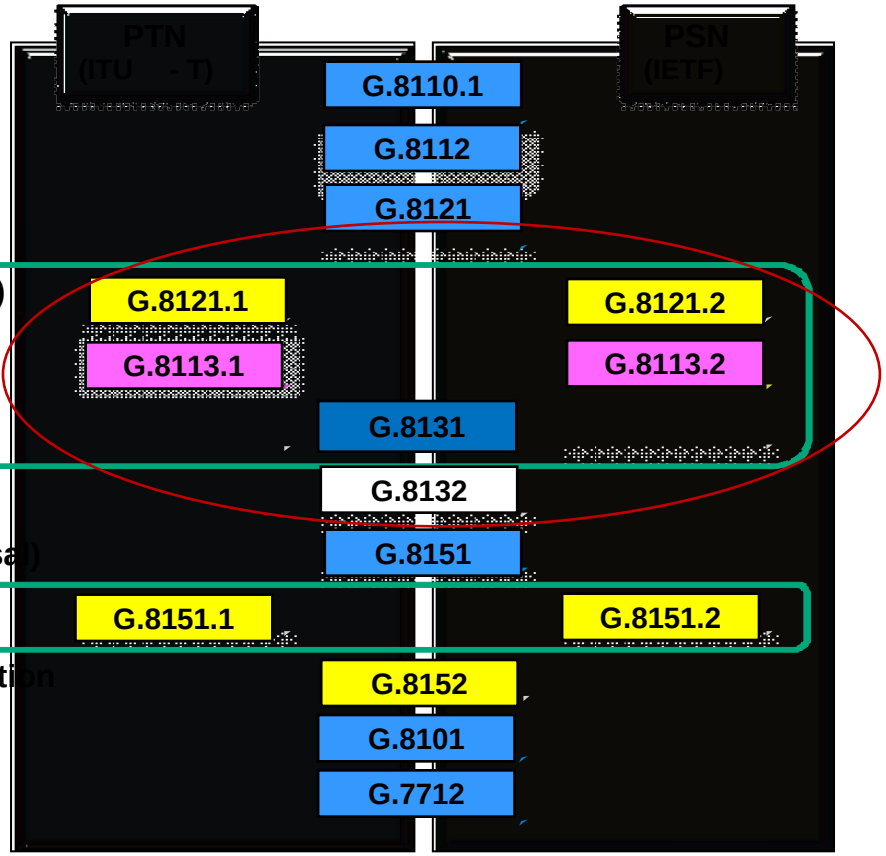
Device function (associated with OAM)

MPLS-TP OAM
MPLS-TP linear protection

MPLS-TP ring network protection
MPLS-TP device management (universal)

Device management (protocol related)

MPLS-TP device management information model
MPLS-TP terms
DCN



WTSA-12 (Approved)

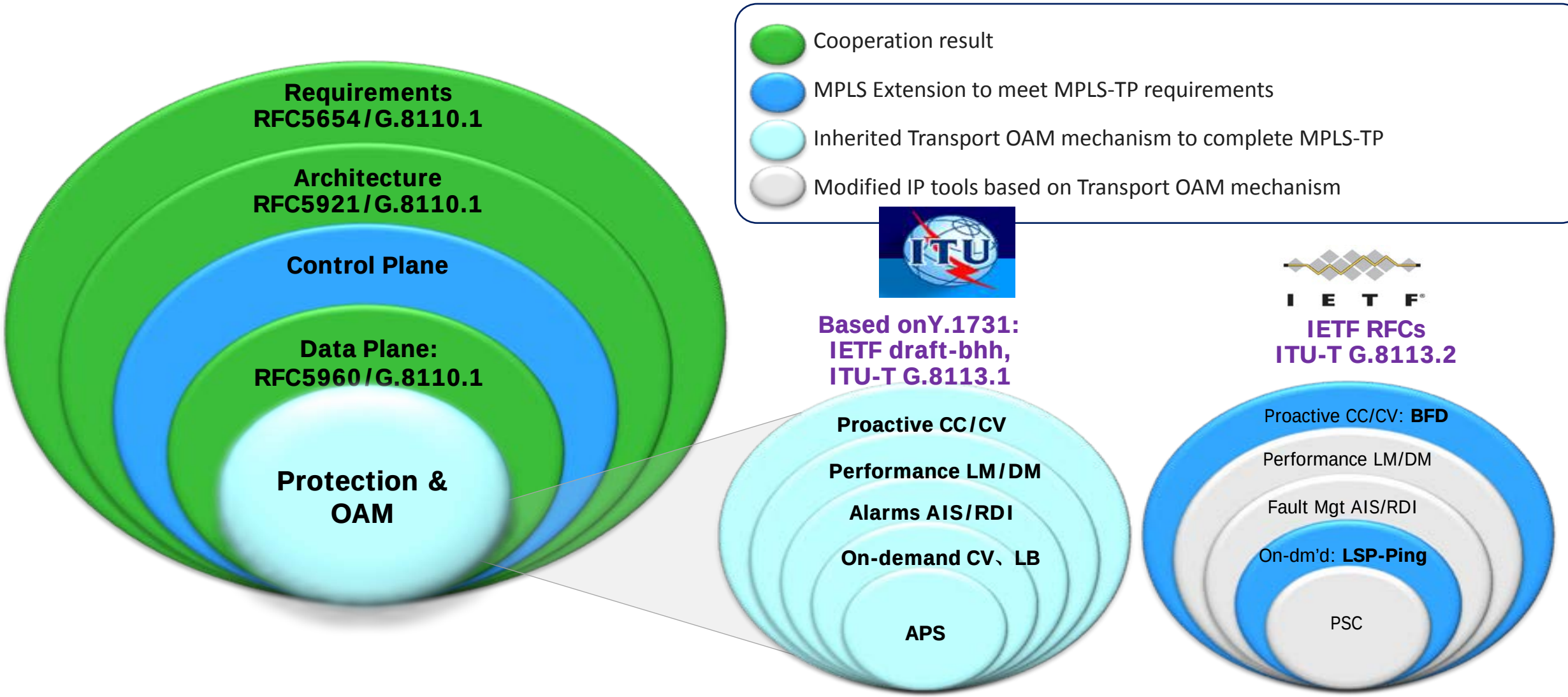
Approved

Consented

In progress

ITU-T G.8113.1 was officially issued in November 2012, which was a milestone of PTN international standardization. It guarantees major benefits of Chinese communications operator and manufacturing enterprises, protects network investment, and helps in exploring market penetration in Asia, Africa, and Americas.

General View of MPLS-TP OAM Standization



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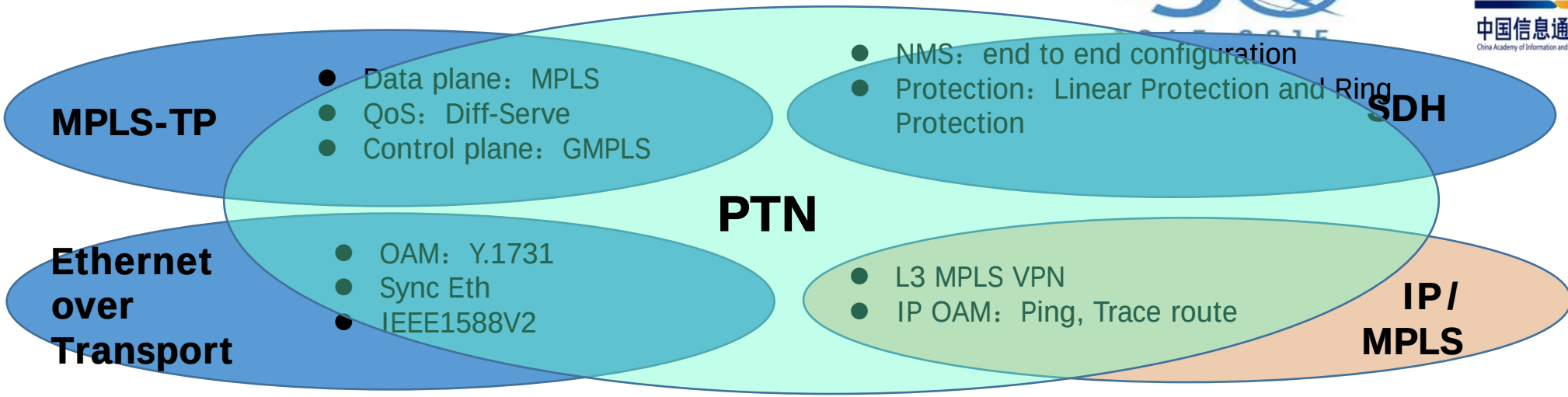
PTN Development in China



T-MPLS Standization

MPLS-TP JWT

Chinese members promot ITU-T MPLS-TP standards.

Promote PTN

From trail to PTN Deployment

2006~2007	2008~2009	2010~2013
CCSA start PTN research project	2010.12 CCSA 1st PTN standard completed	PTN series standards published
CATR Verified PTN for CMCC in Lab	2G/3G Mobile backhaul trail	Metro PTN deployment	LTE mobile backhaul trail	Backbone PTN deployment

PTN Technical Standards have been basically completed by industry cooperation in CCSA

12 CCSA PTN Standard by MIIT (8 of them published)

YD/T 2374-2011 PTN network technical requirements	Architecture
YD/T 2397-2012 PTN device technical requirements	Adaptation
YD/T 2487-2013 Test methods of PTN Equipment	Forwarding
YD/T 2755-2014 PTN interworking technical requirements	OAM
2012-1330T-YD PTN interworking test methods (approved in February, 2015)	Protection
PTN technical requirements oriented for group customer access (approved in November, 2014)	QoS
YD/T 2336.1-2011 six PTN NMS Standards, including function, information model, and management interface (4 of them released and 2 submitted for approval)	Synchronization
	Equipment
	Test
	Interworking
	NMS

- Chinese carriers, institutes, and communication enterprises have teamed up with 12 MIIT industry standards and dominated the setup of 6 ITU-T standards and 3 IETF RFCs, which has laid foundation for PTN development, manufacturing, sales, and operating.

The Progress of PTN Industry and deployment

- The industry chains of PTN are improved and completed, covering chips, equipment, instrument and operators, nearly billions of industry scale formation, realize the transformation of high-tech achievements
- PTN deployment are extended from China to more than 60 countries , more than 1300k equipment are deployed not only in communication network, but also in electrical power network, broadcast network, oil network, railway network, etc.

PTN Industry

Operators ~100

中国移动 China Mobile, TELECOM ITALIA, docomo, Deutsche Telekom, 中国电信 CHINA TELECOM, China unicom中国联通, Telefónica, SK telecom

Vendors 13

HUAWEI, ZTE中兴, 瑞斯康达, Empowered by Innovation NEC, Alcatel·Lucent, FiberHome, UTSTARCOM, H3C

Test Instruments 10

IXIA, SPIRENT, EXFO, OPWILL, Calnex Solutions, JDSU, Anritsu Discover What's Possible

Chips 11

xelerated, HUAWEI, CORTINA, QUALCOMM, PMC PMC-SIERRA, MEDIATEK, ALTERA, centec networks

CMCC PTN

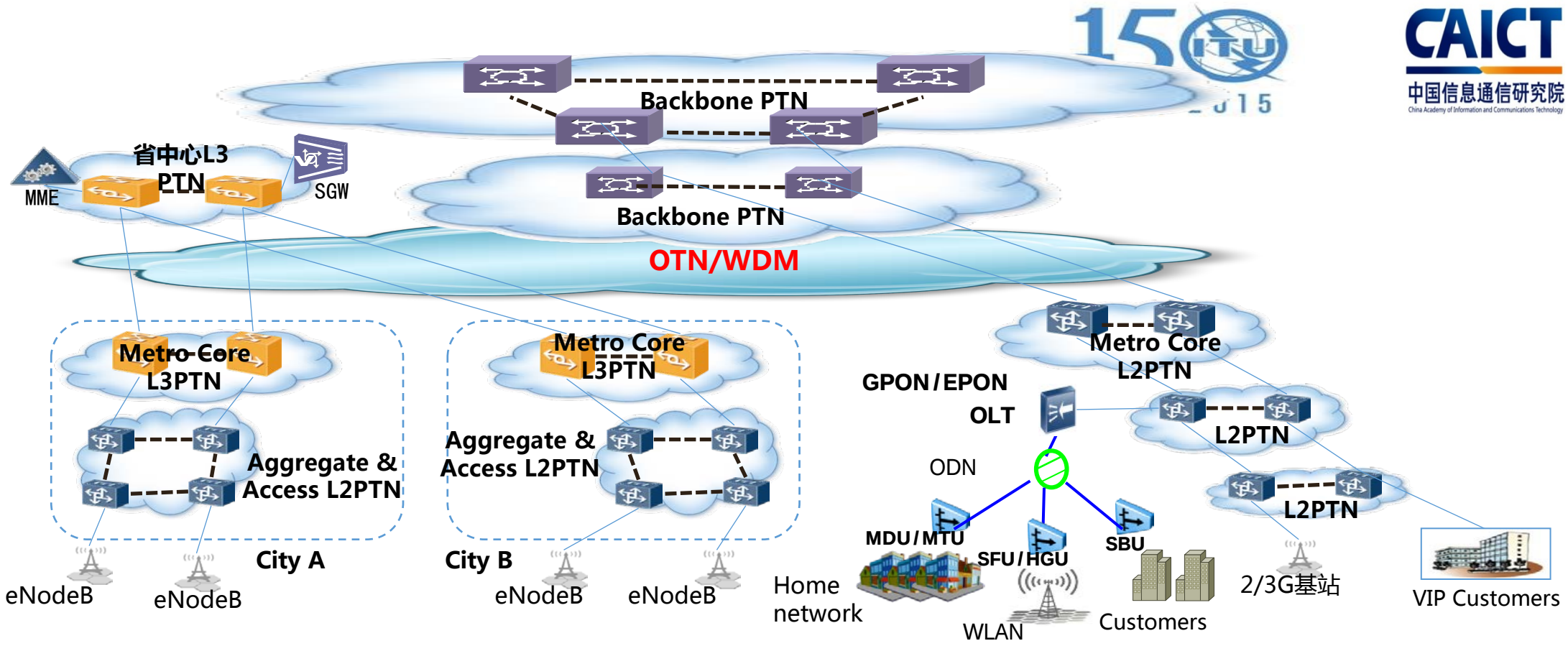
- Deployed more than 700k PTN equipment.
- From backbone to metro and access network, for 2G/3G/LTE mobile backhaul and Business Customers

Global PTN Deployment

Huawei	>603,000
ZTE	>530,000
Fiber home	>154,000
Shanghai Bell	>3,5000

Data source: CMCC in June.2014

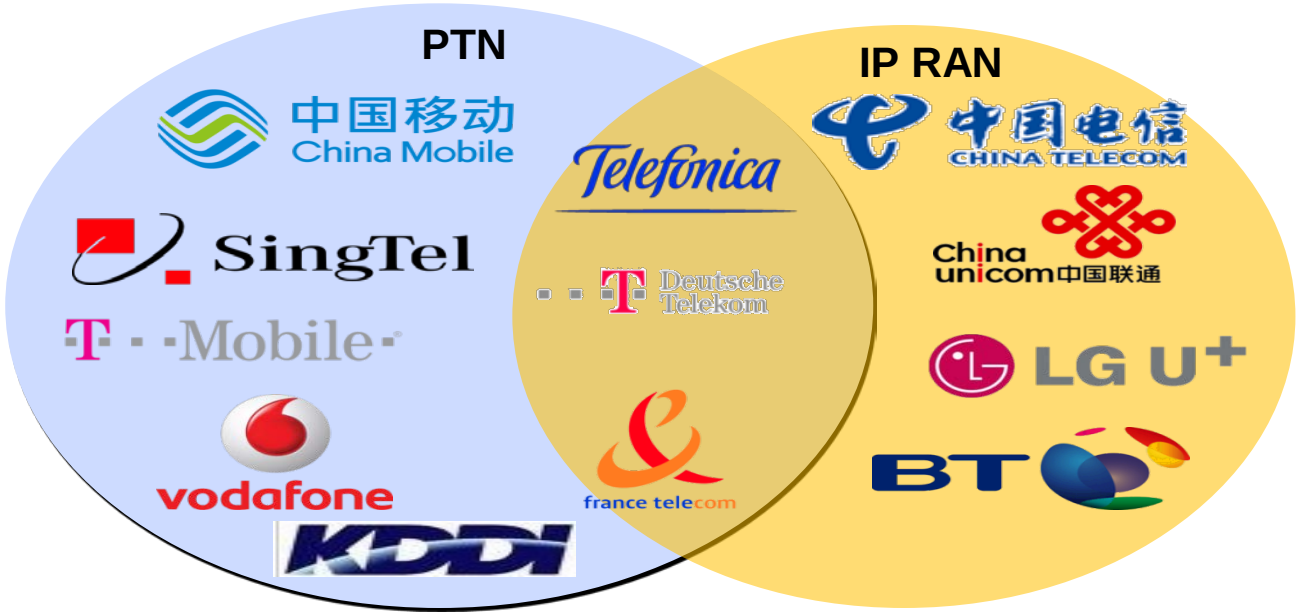
PTN deployment progress of CMCC

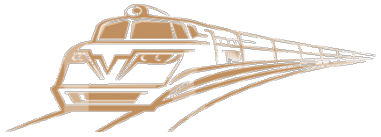


- Since 2009，CMCC has carried out five Centralized purchasing and deployment，covers more than 300 cities, totally more than 700K equipment's.
- PTN mainly for 2 G/ 3G/TD-LTE base station backhaul to
- Metro core & aggregate: 10GE/40GE/100GE; Metro access is given priority to with 10 GE and GE ring .

PTN Technology Ever-evolving in Cooperation and Competition

Bearer technologies chosen by mainstream carriers





Same principle: packet scheduling

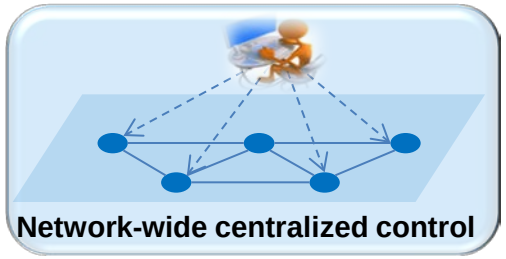
Different choices: implementation mode

PTN = Packet scheduling + SDH OAM experience

IPRAN = Packet scheduling + Routing protocol

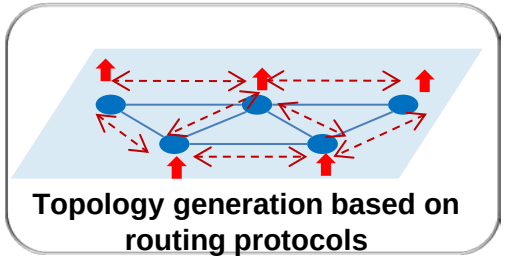
Different control mode

PTN



Network-wide centralized control

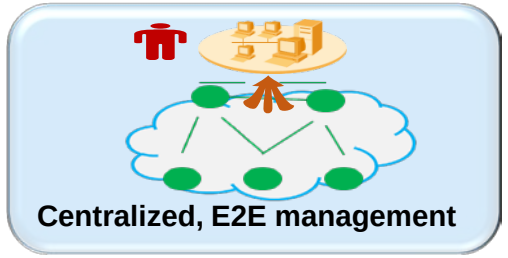
VS



Topology generation based on routing protocols

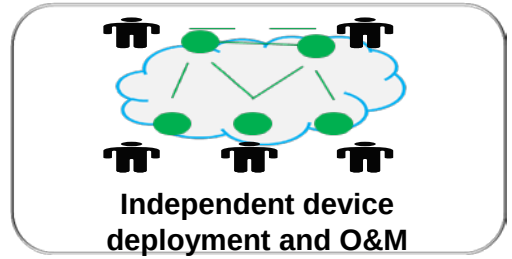
IP RAN

Different OAM modes



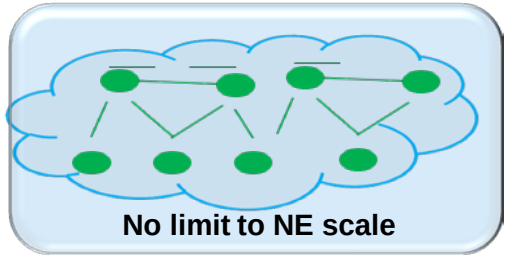
Centralized, E2E management

VS



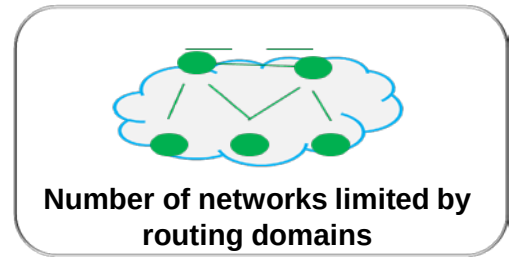
Independent device deployment and O&M

Different networking capabilities



No limit to NE scale

VS



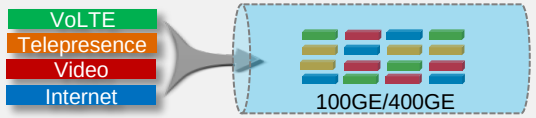
Number of networks limited by routing domains

Development Trend of PTN Technology and Applications in China

Fast and efficient bearer

- Efficient backbone and metro networks: 4*100GE
- High integration: CFP2 and CFP4
- OTN-integrated hybrid line cards

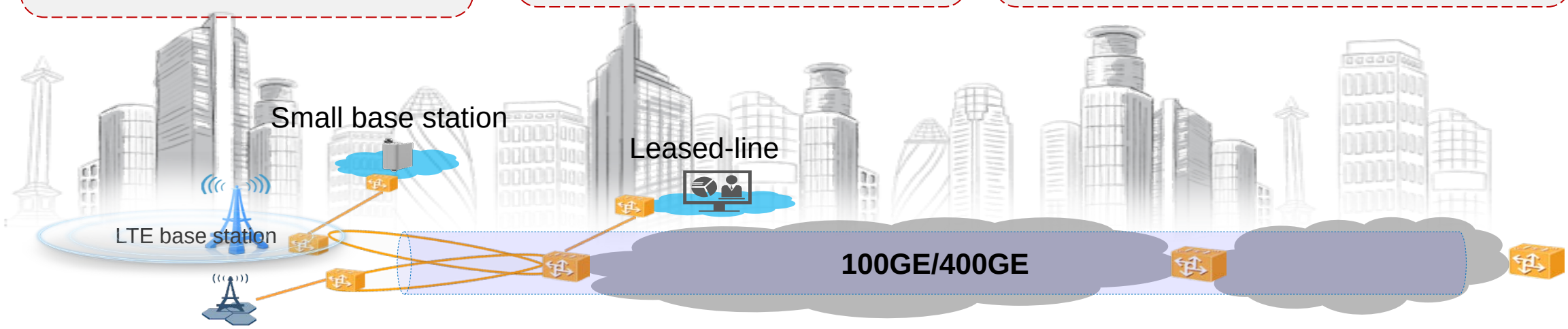
High-quality service



- Support for traffic monitoring of smart pipes
- Service-centric SQM and SLA assurance

Smart and open to SDN evolution

- Simplified O&M on leased-line services and Layer 3 networks
- Fast deployment of inter-domain services
- Open network management and control capabilities
- Improved service awareness



Summary of Part 1

- SDH/MSTP technology, based on TDM circuit switch, has it's limitations in IP traffic dominated era.
- Packet Transport Network based on MPLS-TP technology is the converged migration product of transport network.
- OAM tools are very important mechanisms for all of the packet networks to enhance fault and performance management capabilities.
- ITU-T G.8113.1 is an extension of Y.1731 Ethernet OAM to MPLS-TP network, with the inherit advantages in mature standard and industry supporting.
- PTN have been widely deployed in China, and will be continually improved to meet the requirements of services and network evolution.

Exam questions:

1) What’s the technical limitations of SDH/MSTP in the Packet era?

2) What kinds of MPLS-TP OAM tools has been defined in ITU-T G.8113.1?

3) What’s your opinion and choice for packet transport network technology (IP/MPLS, Carrier Ethernet, PTN)?

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