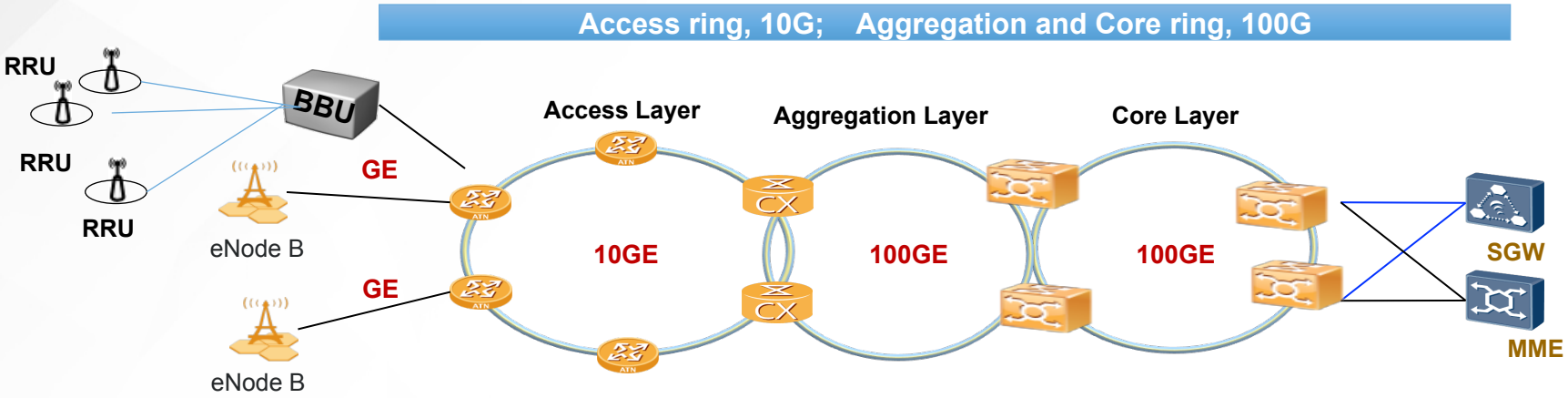
中国移动
China Mobile

The transport network considerations for 5G in CMCC

中国移动5G联合创新中心
China Mobile 5G Innovation Center

China Mobile Transport Network for 4G

- **PTN Backhaul:** More than 2M PTN nodes for Macro cell, Micro Cell and Pico cell; L3 in core layer for X2 and S1 Flex
- **GPON backhaul:** integrated Pico and femto Cell
- **Fronthaul:** ~5RRUs/BBU, is mainly based on fiber direct connection



Bandwidth plan for single S111 eNodeB	Access Layer 80 Mbps	Aggregation Layer 60Mbps	Core Layer 40Mbps

Latency requirements of 4G backhaul	single direction of transport network: 10ms single equipment : 100us	**Test results in PTN field network**	single direction of transport network: ~2ms single equipment : ~50us
Time Sync requirements of 4G backhaul	time servers are only deployed in metro end-to-end Sync precision : ±1.5us	**Test results in PTN field network**	end-to-end Sync precision : under ± 500ns

5G new scenarios bring new challenges to transport network

5G new scenarios

eMBB

uRLLC

mMTC

New challenges to transport network

Networking architecture Changes

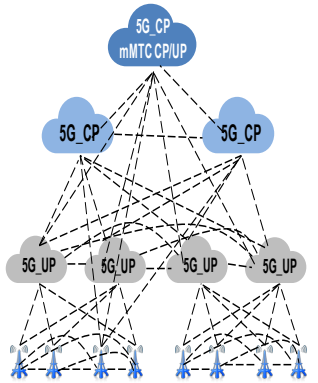
5G RAN:

CU/DU decouple

5G Core:

Cloud core network, UPF sink, MEC

Connections between network element devices ***change into*** **The interconnection between clouds, which needs to be unified and flexible.**



Service Requirement Changes

Bandwidth

320M->10G bps/Single Station

Delay

10ms->1ms One-way Delay

Slicing

For different service types and attributes

Sync

1.5us->400ns Time Sync.

infrastructure Requirement Changes

Fiber:

The density of the site is higher, which promotes the pressure of the terminal fiber.

Machine Room:

More new equipments, higher requirements for room, power supply and heat dissipation.

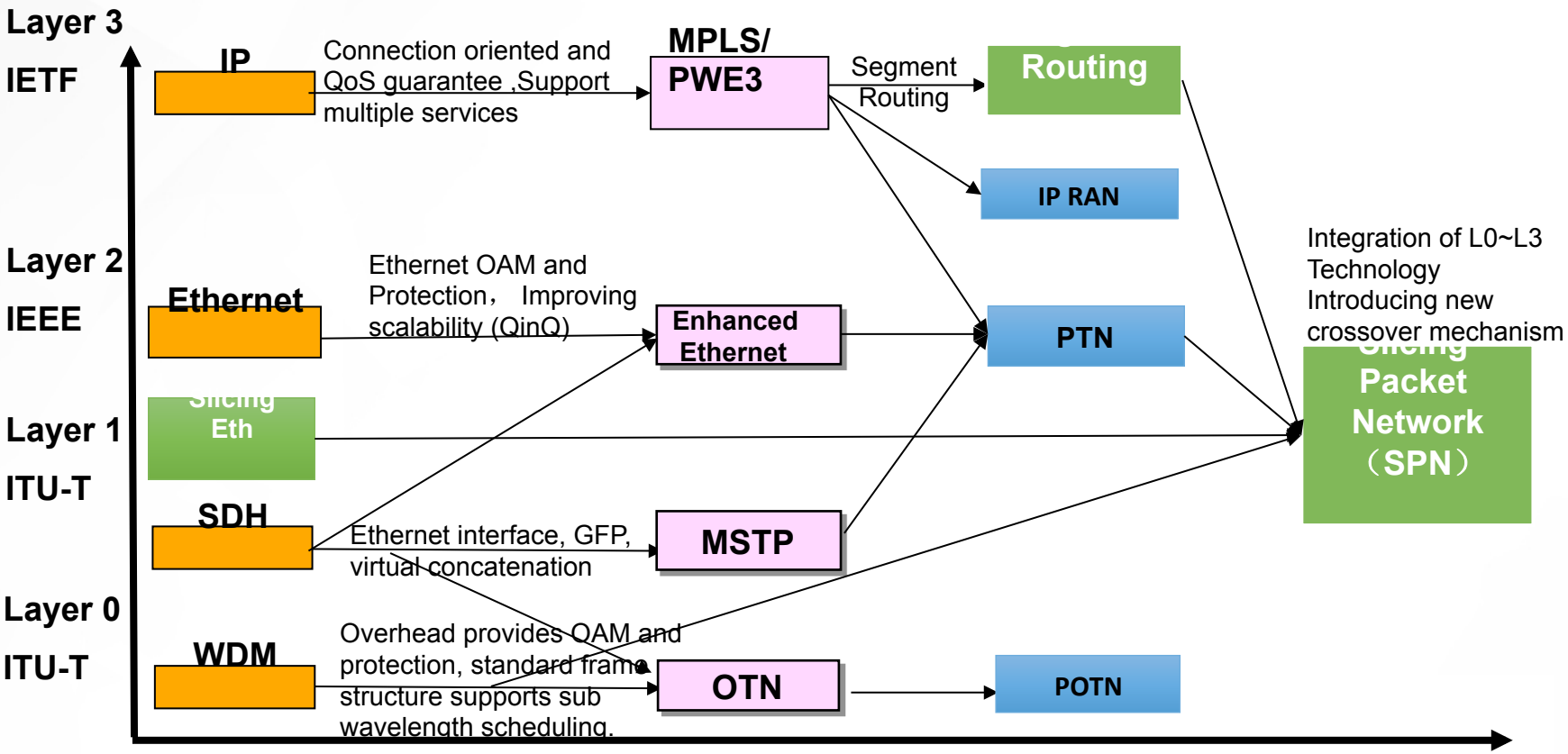
◆ The infrastructure, architecture, bandwidth, delay, synchronization and other requirements of 5G transmission network have changed greatly and need to be re-architected.

The Consideration of the network evolution

① follow the trend of IP-based network, and make full use of the advantages of Ethernet ecosystem chain to reduce costs in the optical and electrical layers.

② For large bandwidth and flexible forwarding demand, multi-layer resource collaboration is required, L0~L3 capability should be integrated at the same time.

③ For ultra low latency and vertical industries, soft and hard isolation chips are needed to support TDM and packet switching.



Slicing Packet Network to meet 5G transport new requirement

Bandwidth ↑ 100 Times | **Latency ↓ 100 Times** | **Per bit cost ↓ 10 Times**

SPN (Slicing Packet Network) is a new transport technology profile, which include new protocols, new optical and new control.

New Protocol

- Slicing Ethernet
- Cost Effective (Opex)
- Reliable
- SR-TP
- Flexible

New Optical

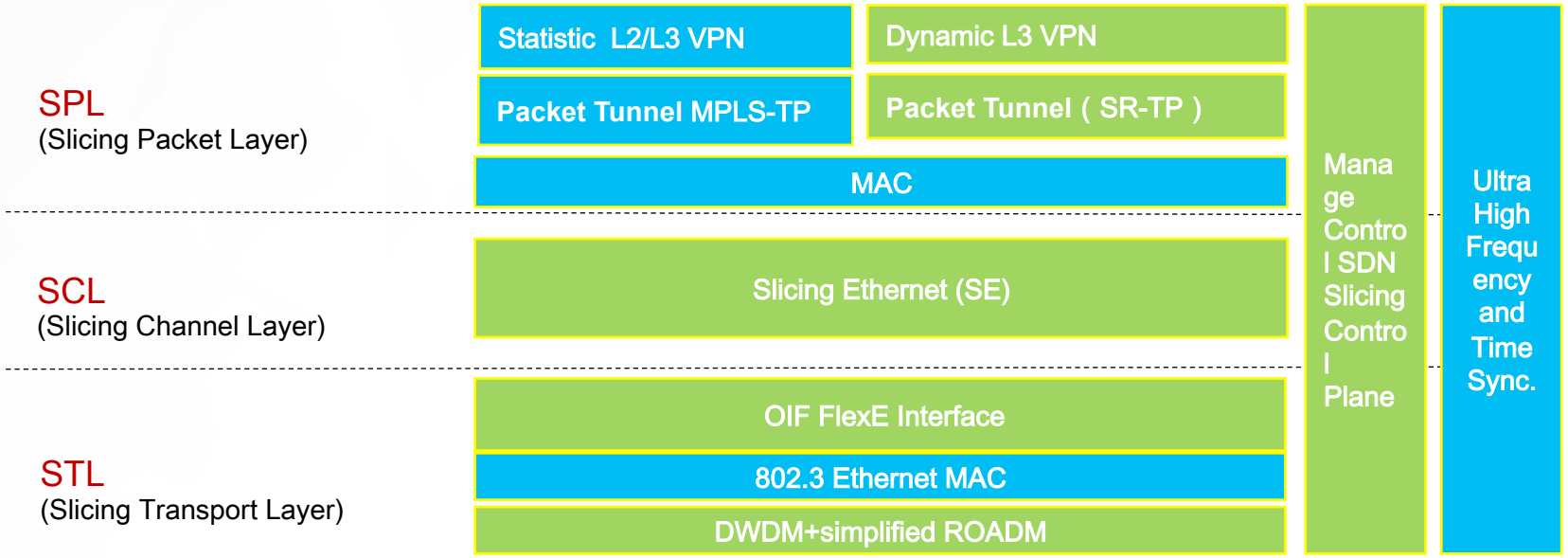
- 50GE
- PAM4
- N*100GE
- DWDM
- Cost Effective (Capex)

New Control

- SDN
- Orchestrator
- South and North Interface
- Wireless and Core Network
- Centralized Control

Architecture: SPN integrates L0~L3 multilayer functions

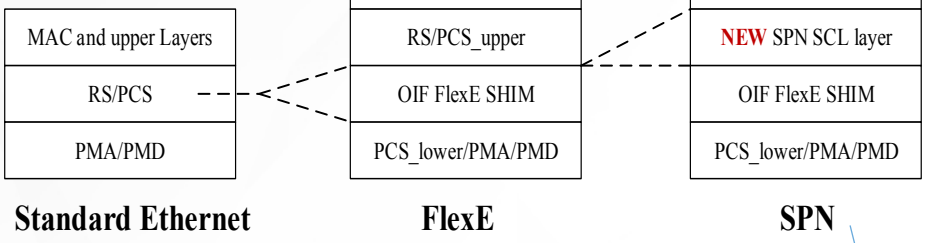
- SPN is a new generation transport network designed for 5G. It is a photoelectric fusion device. It can realize intelligent slice scheduling by SDN.
- L2&L3: The packet layer guarantees the flexible connection ability of the network and flexibly supports MPLS-TP, SR and other packet forwarding mechanisms.
- L1: The channel layer realizes lightweight TDM crossover, supports 66b based fixed length block TDM switching, and provides packet network hard slices.
- L0: Transport layer realizes Ethernet of optical interface, accesses PAM4 gray light module, and the DWDM network.



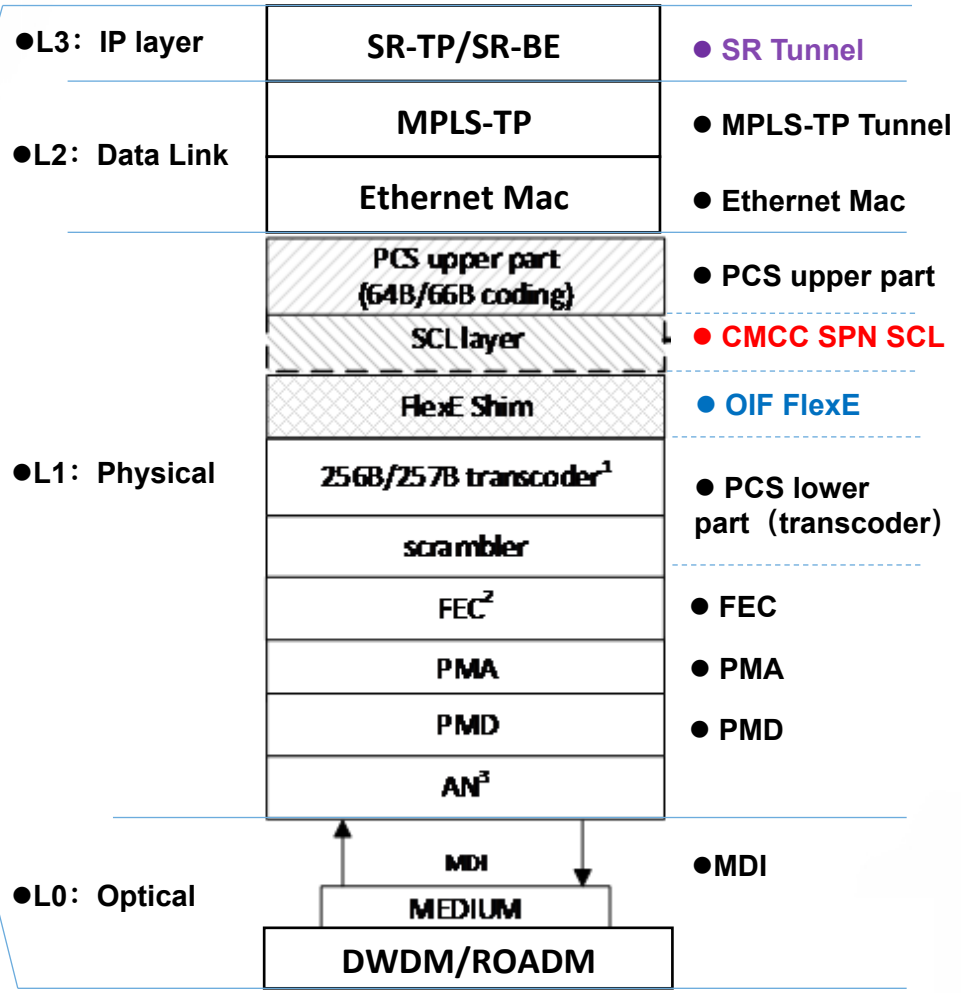
Legend : Inheritance of PTN function SPN New functions

Architecture: SPN protocol stack architecture

SPN layer structure evolution



SPN protocol stack architecture

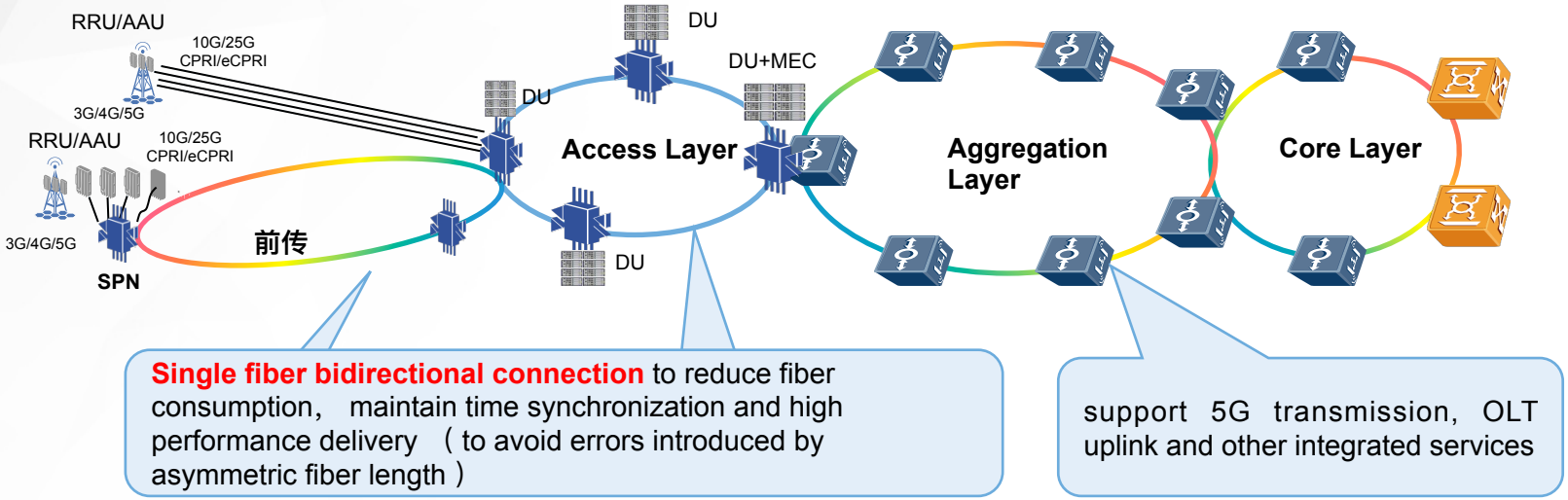


SPN innovatively introduces SPN channel layer, integrates TDM and packet switching, and integrates L0 layer to L3 layer into a whole.

Transport Layer： Ethernet Optical Layer Interface Requirements

- **Fronthaul Requirements**: fiber direct drive, large core fiber,25GE BIDI module
- **Middlehaul/Backhaul(small city)**:E2E gray Ethernet networking， 50GE PAM4*N
- **Middlehaul/Backhaul(large city)**:access with gray Ethernet， aggregation / core with DWDM

Networking Scheme

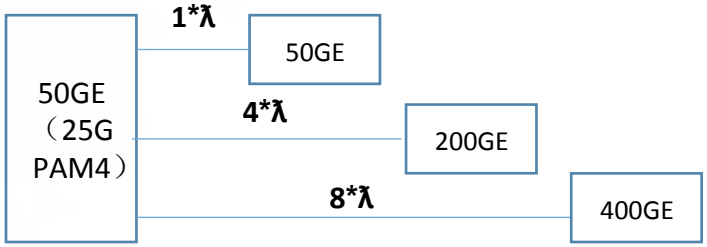


Single fiber bidirectional connection to reduce fiber consumption， maintain time synchronization and high performance delivery （to avoid errors introduced by asymmetric fiber length）

support 5G transmission, OLT uplink and other integrated services

Interface Technology

Gray Ethernet module requirements



Distance： •2km •10km •40km

Color Ethernet module requirements

- Coherent Ethernet Color Light Module
  - 400G ZR
  - 200G ZR
  - 100G ZR

- Distance： •80km •120km

Transport Layer: Optical Considerations

- SPN as a 5G mobile oriented integrated transport network for metro application would raise reasonable requirements for its optical components

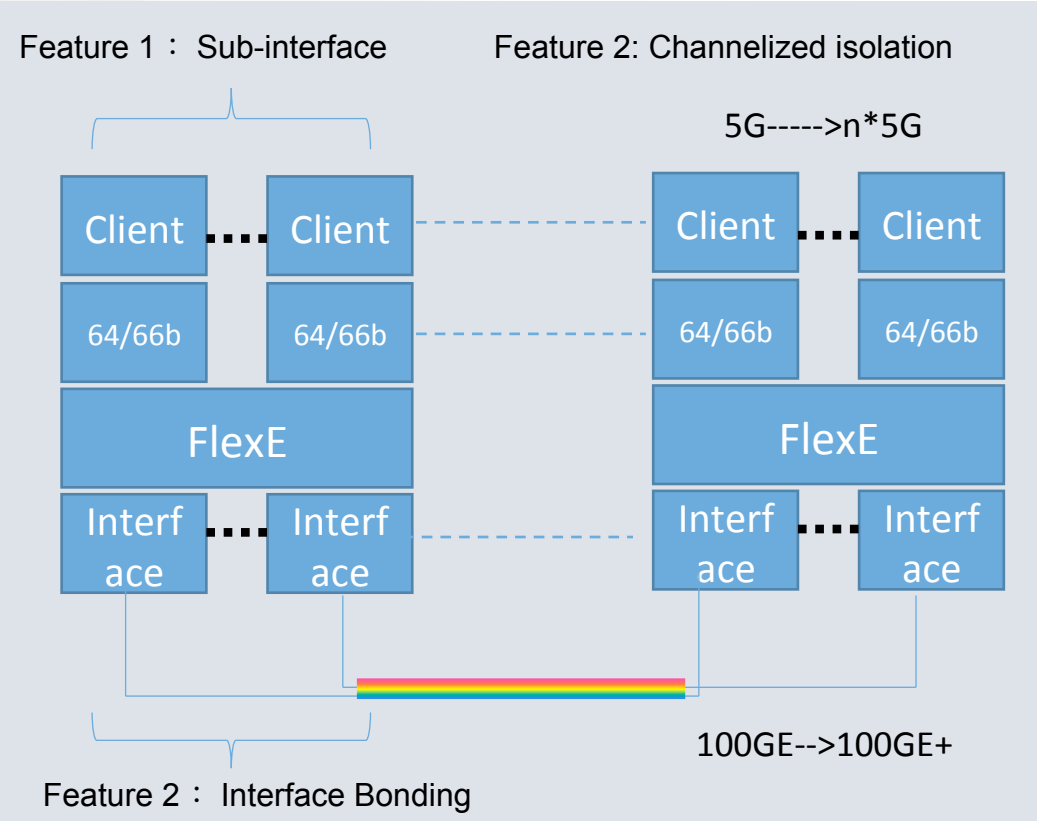
50Gbps PAM4 Grey Optical	SPN access/metro aggregation would heavy drive the volume of IEEE 50GE/ 100GE/200GE grey optical, e.g. would provide broad market potential for the new 50Gbps PAM4 grey optical (n Lanes)
Single fiber Bi-Directional	Would prevent optical signal delay asymmetry for supporting SPN high accuracy synchronization.
Coherent Colored Optical	SPN metro aggregation /core is a key application scenario for 100/200/400G per lambda High speed/BW coherent optical at about 80~200km, e.g. 400G ZR
Silicon photonics	SPN is also a key application scenario for silicon photonics due to low power consumption, high density and economic efficiency considerations

SPN provide broad market potential for the new generation optical industry for the next 5+ years

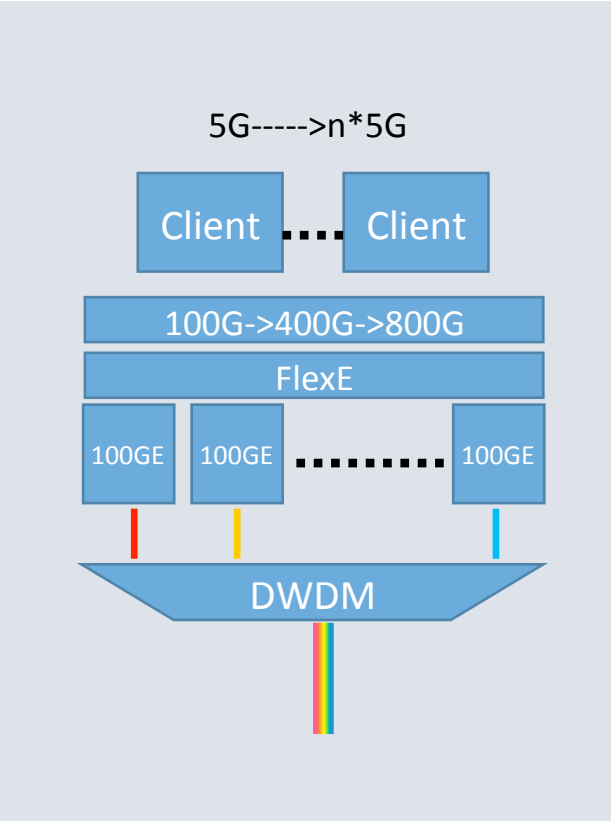
Transport Layer: DWDM Colorful Ethernet and FlexE

FlexE and DWDM enable flexible expansion and segmentation of bandwidth

FlexE over WDM Networking



FlexE and DWDM

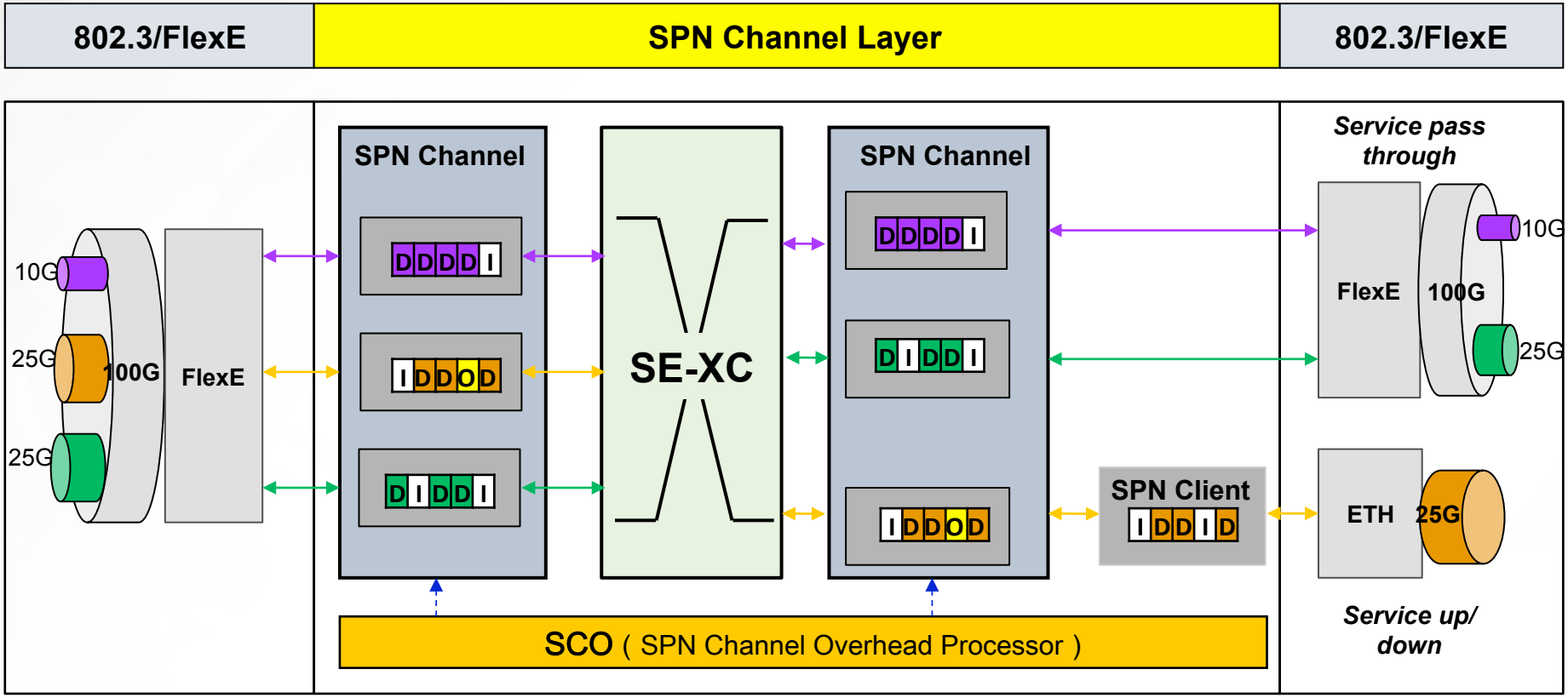


- FlexE supports bandwidth that exceeds the physical interface rate through multiple interface bonding
- FlexE+DWDM not only provides single-fiber large-bandwidth capability, but also combines DWDM channels to flexibly increase bandwidth on demand
- FlexE supports sub-interface channelization with n*5G bandwidth to achieve network slicing

Path Layer: Slicing Channel Layer（SCL）overview

■ **Slicing Channel Layer（SCL）** Providing **low latency, hard-isolated** slice channels based on L1 for multi-service.

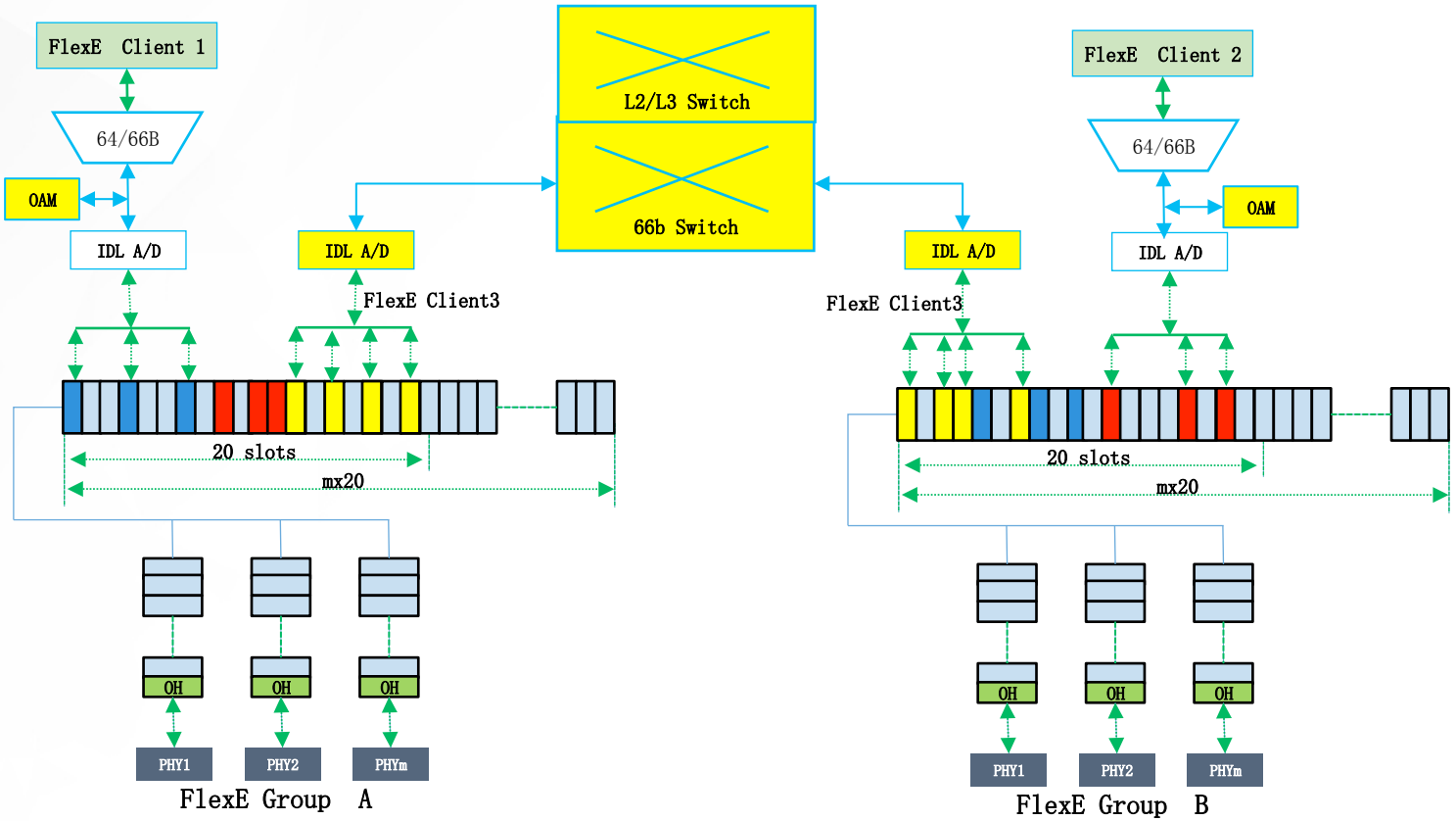
- **SC：SPN Channel**，based on the Ethernet 802.3 stream, the end-to-end slice channel L1 is implemented.
- **EXC：Ethernet Cross Connection**，66bit block cross connection based on TDM slots
- **SCO：SPN Channel Overhead**，based on 802.3 code block expansion, replace IDLE code block, to achieve SPN Channel OAM function.



Path Layer: the cross connection and OAM

New Switch: based on 66bit Slot which is the basic block of original Ethernet

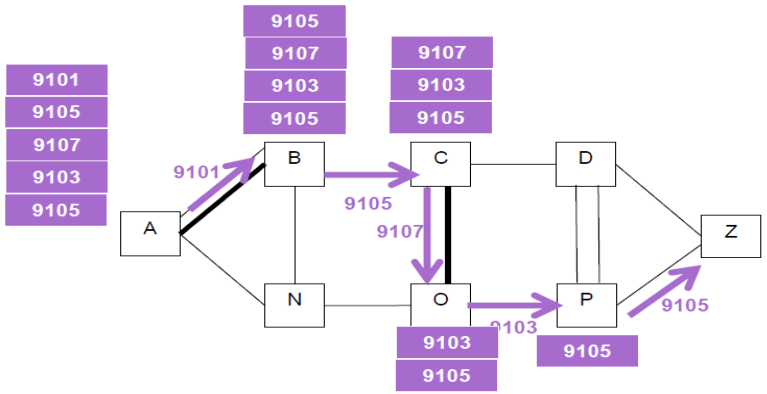
New OAM: Using the IDEL block slot as the OAM message block slot and provide OTN like OAM



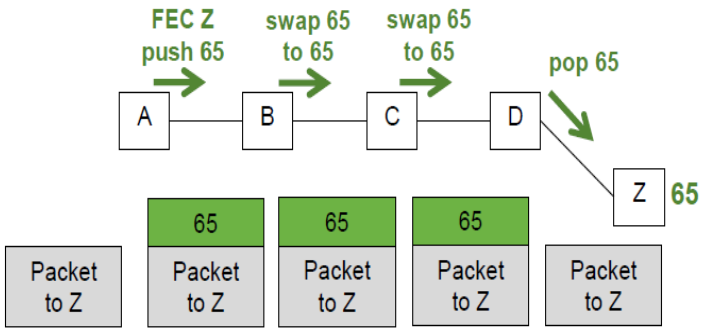
Packet Layer: SR-MPLS Solution

- SR-TE provide the simple E2E L3 VPN solution without complicated protocol such as RSVP and LDP. SR-BE provide the simple solution for flexible connection
- Current SR solution need carrier-grade service guarantee with E2E OAM, we introduced the path segment and binding label to build Segment Routing Transport Profile(SR-TP)

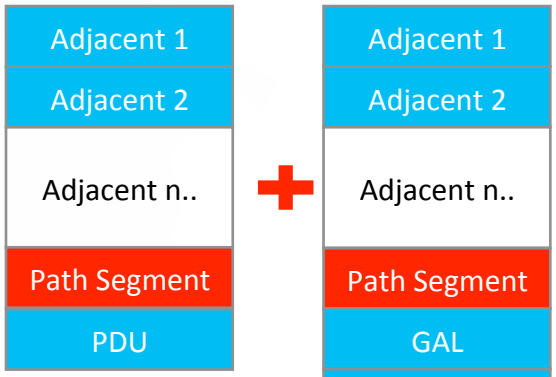
SR-TE（adjacency label）



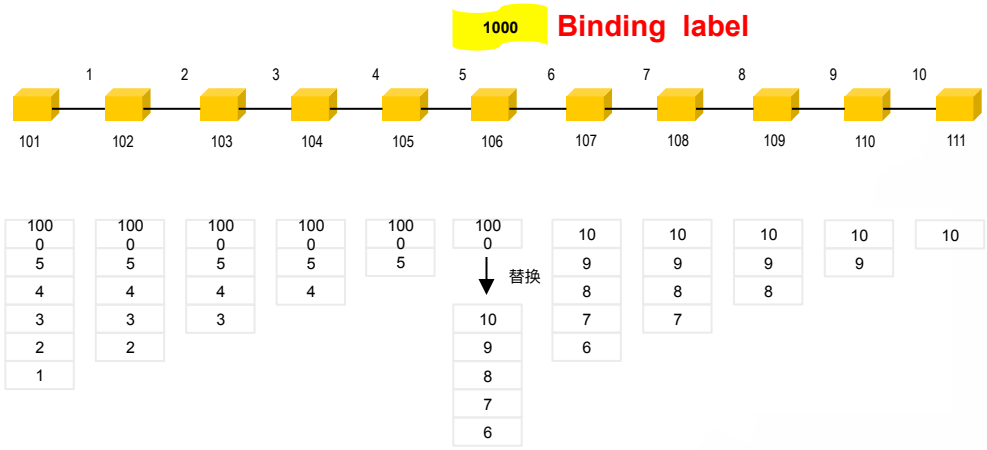
SR-BE（Node label）



Path segment for Connection oriented OAM



Binding label to support more hops

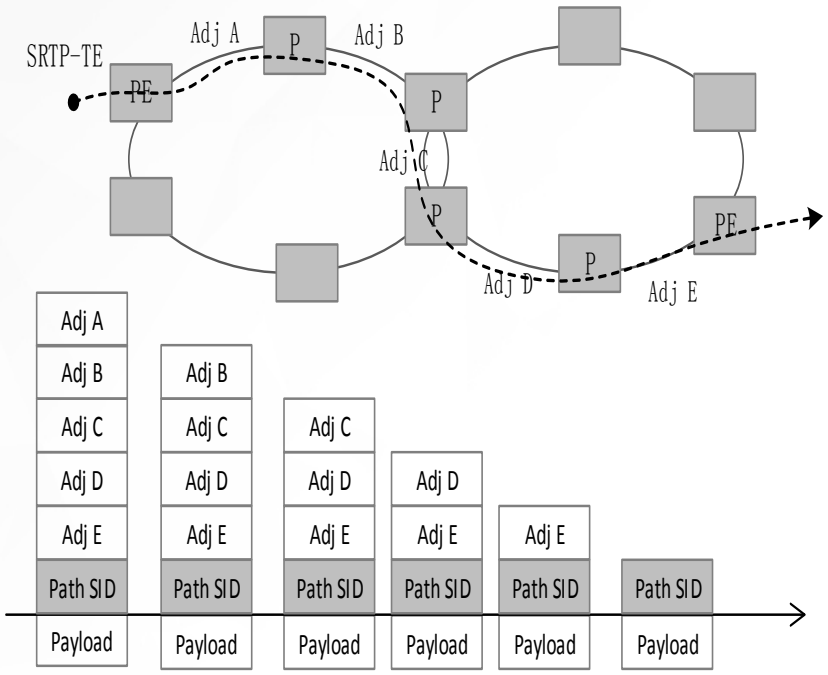


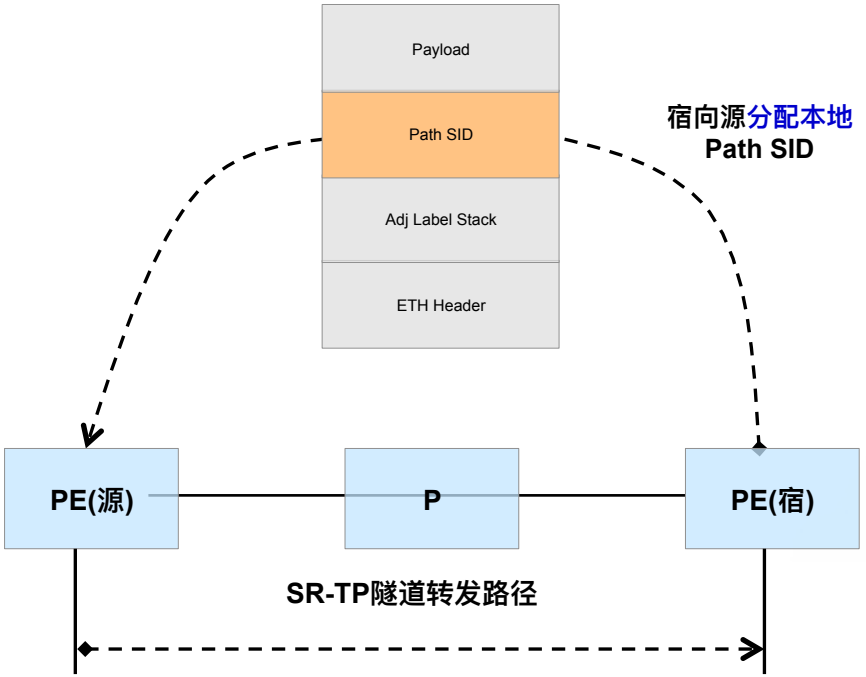
Packet layer： Path Segment solution

SR-TP： On the basis of SR-TE, we adds a layer of Path SID to guarantee the path of SR can be monitoring.

Path Segment： **Path segment for Connection oriented OAM**

Path SID Distributed： the destination nodes distribute the Path SID to source node





Time Sync: enhanced sync requirement

4G Sync

TD-LTE: ±1.5us

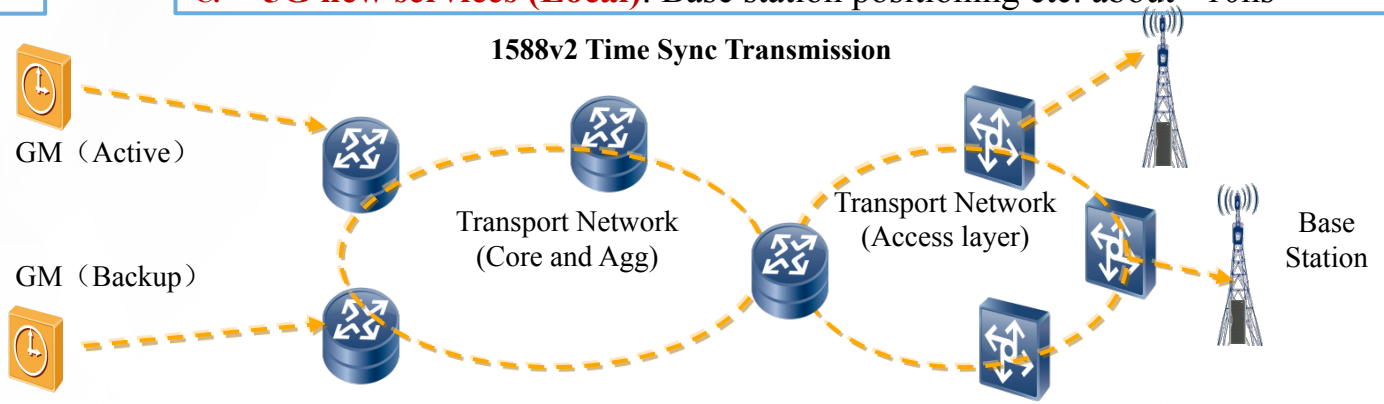
5G Sync

A. **Basic radio interfaces (Whole Network)**: Ultra-short Frames, about ±390ns

B. **Cooperations among stations (Local)**: CoorapCA, CoMP etc., about ±130ns

C. **5G new services (Local)**: Base station positioning etc. about ±10ns

Sync Model

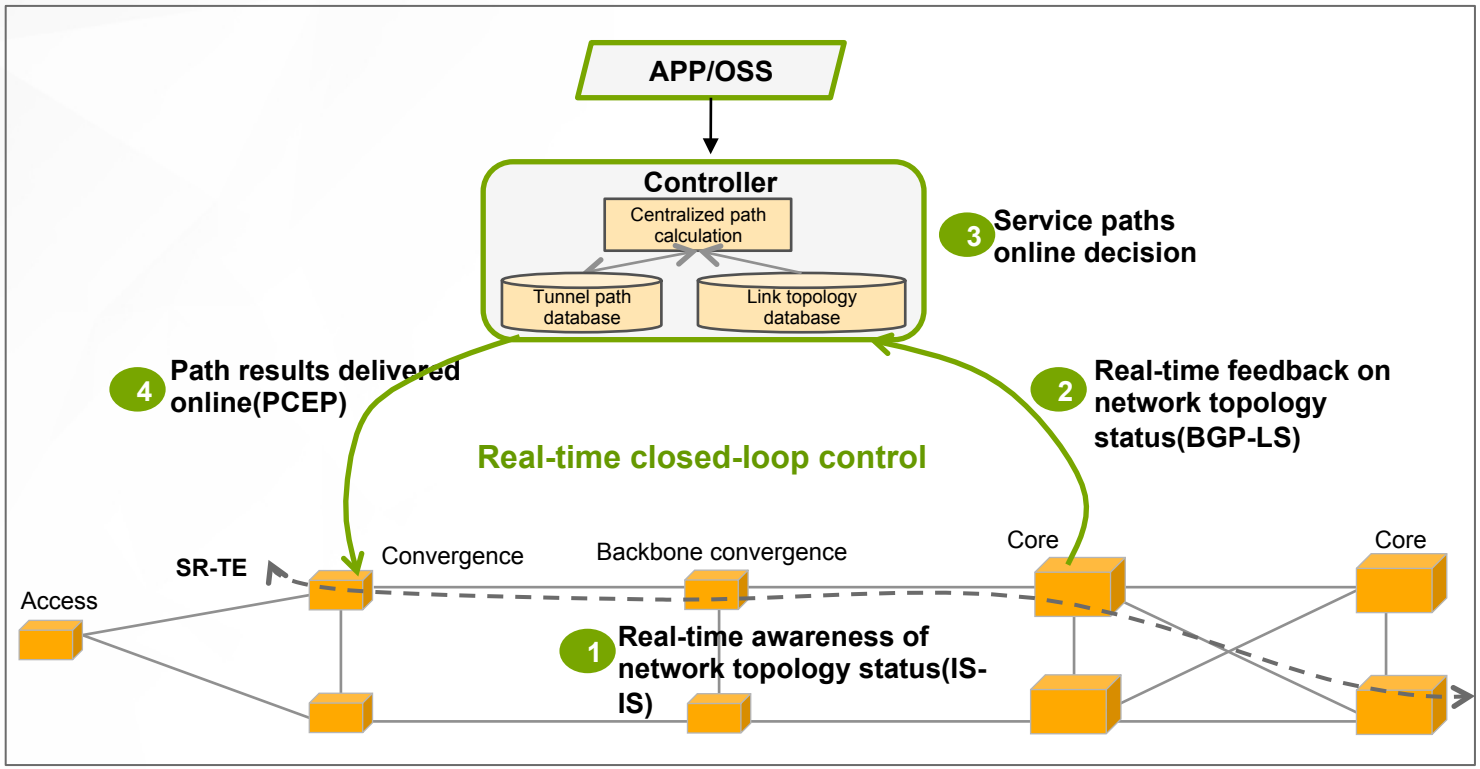


Network budget	PRTC	Transmission Network	Base Station
4G	250ns	1000ns（including holdover），30ns per hop，>20 hops	250ns
5G	50ns	Tracing 100ns，5ns per hop，>20 hops	50ns

- Fronthaul, mid-haul, and backhaul should support time sync functions. End-to-end budget could be +/-200ns without holdover
- The multi-lane interface need to be supported and BiDi modules should be used in front haul and access layer of backhaul
- Compared with 4G, innovative time source and time transmission technologies are required to improve time sync precision.

Control Layer: SPN Control Plane Solution

- Functional Requirements： SPN enhances service dynamic capabilities through SDN centralized control plane
- Design Ideas：“Integration of management and control, centralized control supplemented by distributed control“

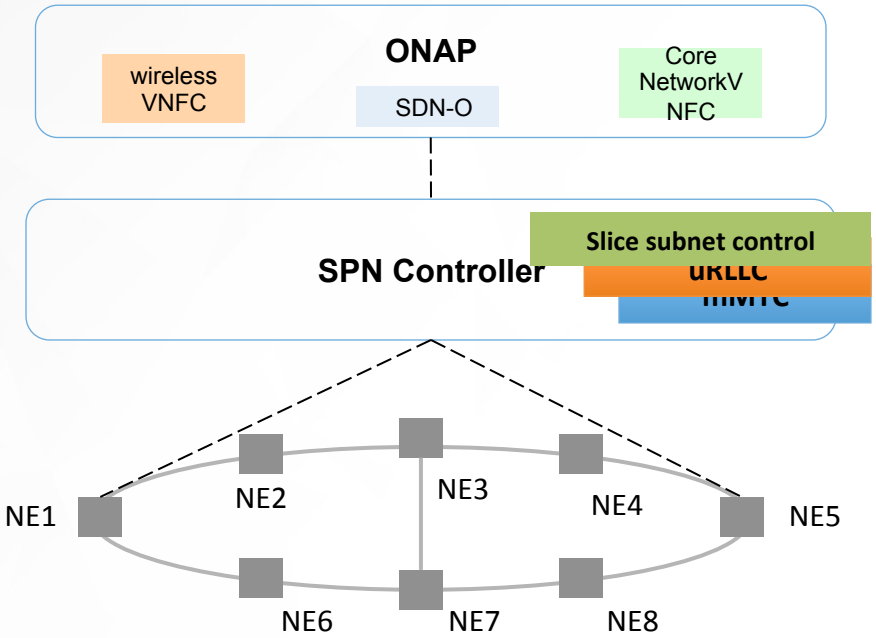


With the combination of IS-IS、BGP-LS and PCEP protocols, SPN realizes real-time closed-loop control of service paths.

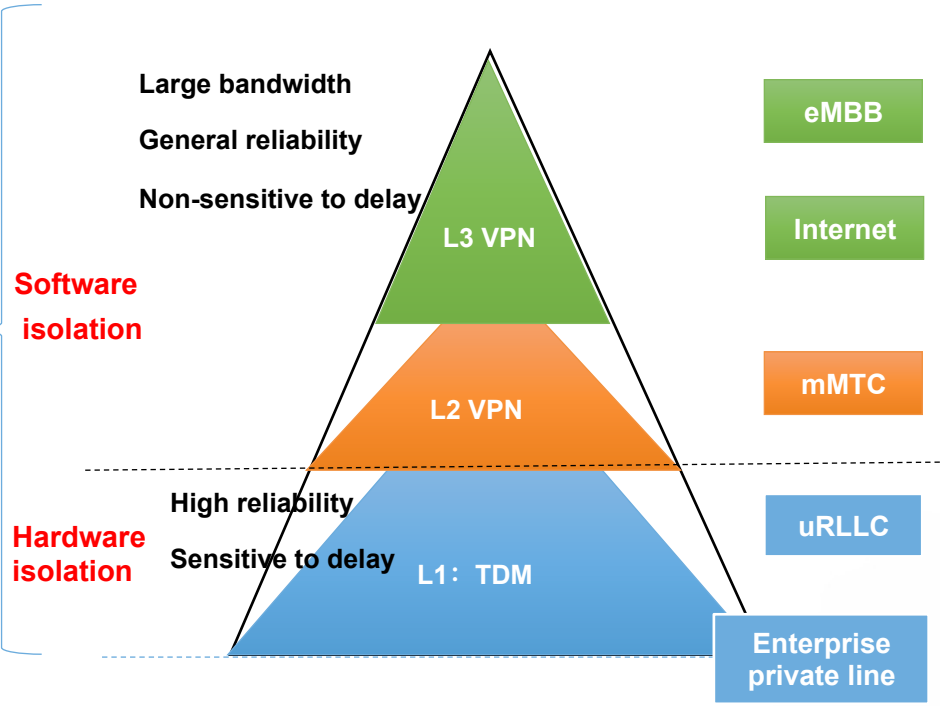
Slicing control： Centralized Controller Achieving Network Slicing

SPN Network Slicing： With the management and control plane integration, SPN implements logical abstraction of physical resources , achieving "one physical network and multiple networking architectures".

SPN Physical Network View

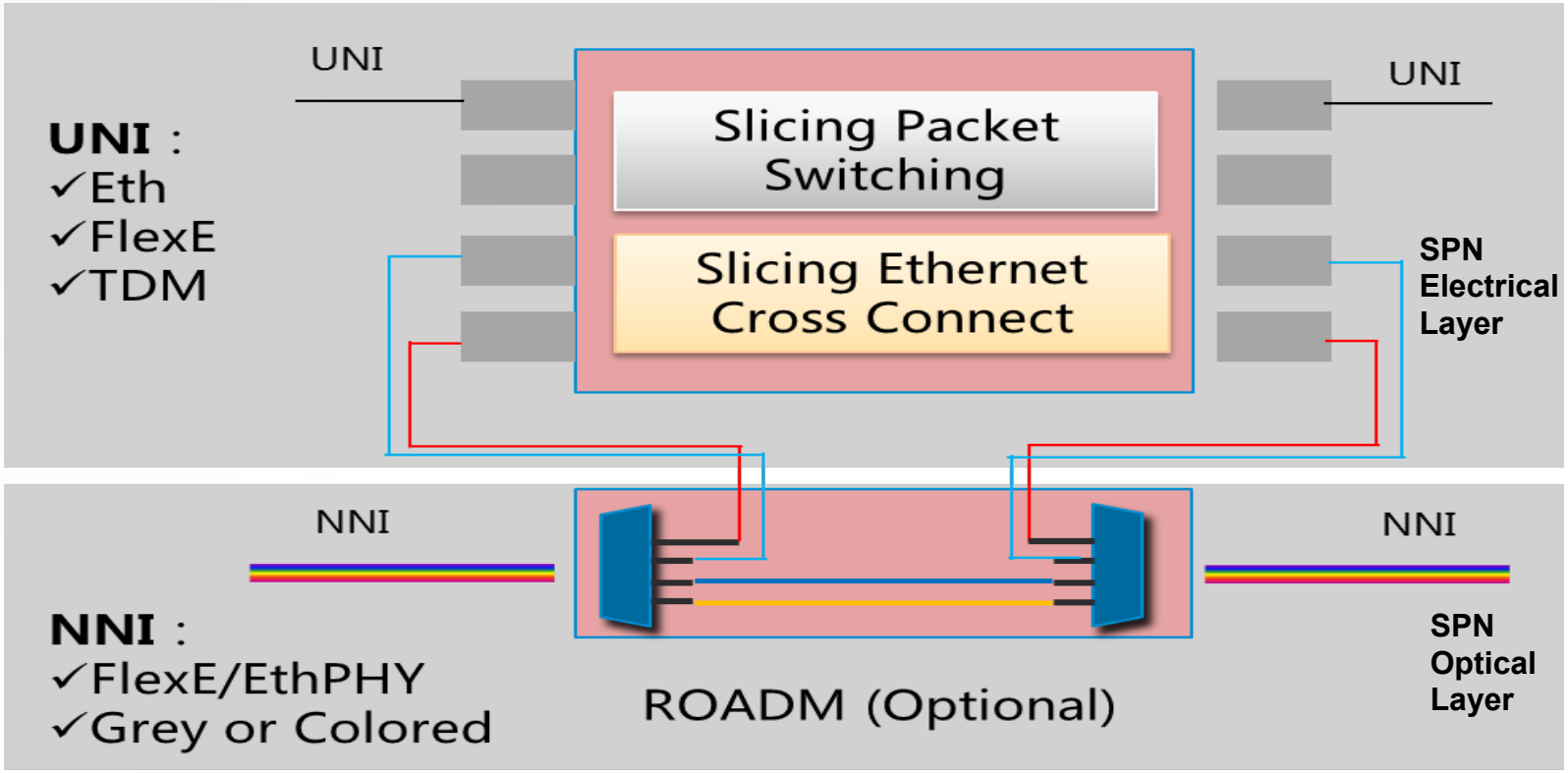


SPN Network Slice Presenting



Considerations on SPN Equipment

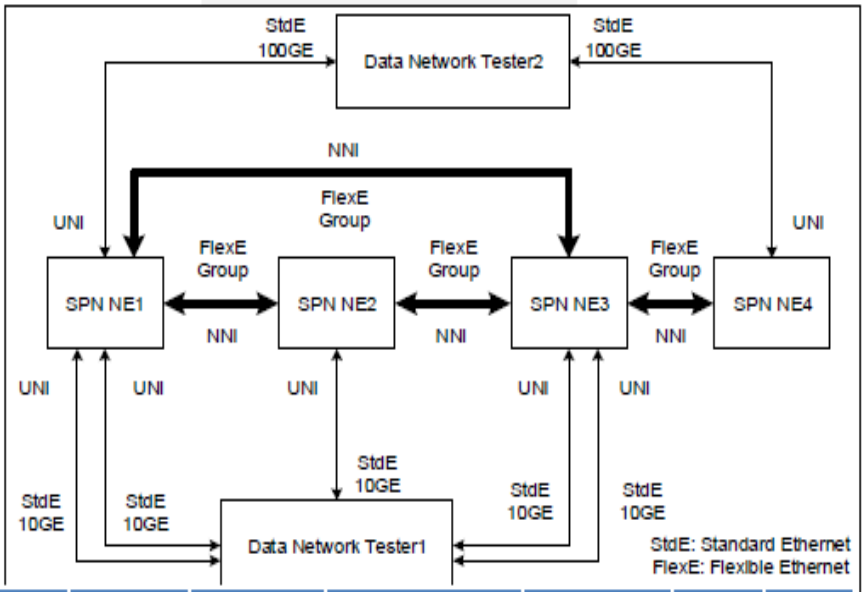
- Packet Switching and Slicing Ethernet cross connect (Required) should be supported and mutual integrated.
- ROADM (Optional), to achieve wavelength switching, save the optical module. It is recommended to use low-level crossover to support static configuration only ;
- Building block design: The electrical layer and the optical layer of the Equipment can be a flexible combination according to the application scenarios.



Lab test on the SPTN

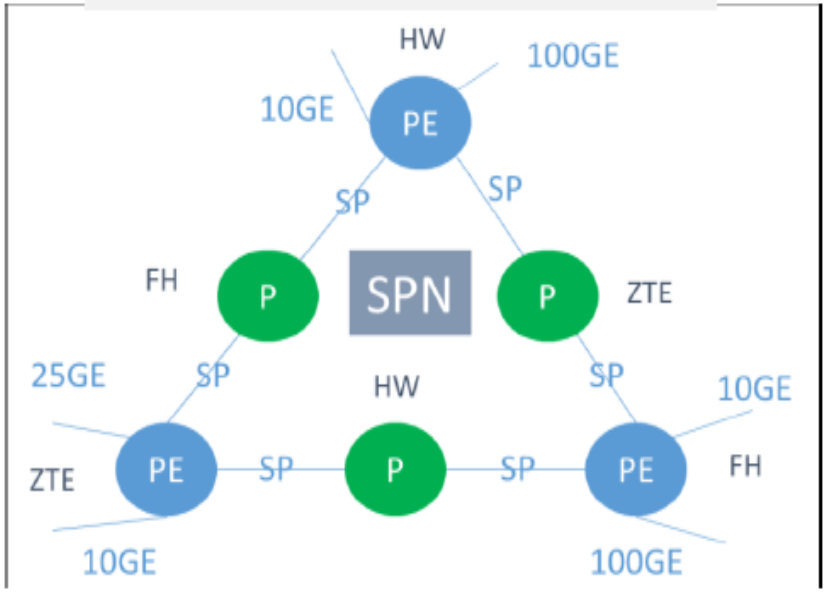
Lab Test have been done in China Mobile lab, and the test result is very good.

Single vender test



	Slot Switch	phy isolation	Latency (Min)	jitter	OAM	Protection
Box	Support	Support	P (~0.5us) PE (~1.0us)	~10ns	Support	~1ms
Chassis	Support	Support	P (~2us) PE (~10us, with L2/L3 enabled)	~250ns (with L2/L3 enabled))	Support	~1ms

Muti-vendors Interoperation test



	Slot Switch	NNI interface	latency	Jitter
PE-P-PE	2	100G	4.48/4.485 us	0.003/0.003us
PE-P-PE (with L2/L3 enabled)	2	100G	18.4/18.5us	0.2/0.2us

SPN Standardization

Suggestions: ITU-T SG15 lead the standardization of SPN and work together with other SDOs to setup the overall SPN standards .

- **SG15 Q11: G.mtn defining the interface, Frame format and OAM, New work item have been setup last week in Geneva.**
- **SG15 Q9: SCL SNC protection.**
- **SG15 Q12: SPN Architecture**
- **SG15 Q13: The New Sync technologies**
- **SG15 Q14: SCL and overall SPN management aspect.**
- **SG15 Q6: Optical Aspect support Ethernet interface signal over WDM, especially for Ethernet PHY data rate at 50Gbps.**

- **Functions of Segment Routing for transport network should be considered.**

ITU-T SG15 has create the new work item for SPN to define the path layer and section layer of SPN and it plans to set up a series of standard to define SPN further.

Maturity of SPN Industry

➢Key processes of the SPN industry

December 2016	April 2017	September 2017	January 2018	February 2018	Sep. 2018
5G Transport project initiation	**Specify the SPN** technical system	Multi-Vendor **SPN Lab test**	**ITU-T** SPN standard initiation	SPN **White Paper Release**	**SPN Field test** with 5G wireless

➢SPN Industry Chain

Equipments

Chips

Test instruments

Summary

5G transport network is facing requirement on re-architecture.

- The unified transport solution for fronthaul, mid-haul and backhaul makes the network maintenance easier and more efficient

Key technologies for 5G transport network

- New Architecture:
  - SR-TP over Slicing Packet over DWDM
- New link layer:
  - End-to-end slicing
  - Link aggregation
  - Channelization
- New packet layer:
  - SR-TP
  - Carrier grade L3
  - SDN

Lab Tests and field trials verification

- Lab tests results show that the SPN can meet the 5G requirements
- SPN Field trials is running in CMCC field network

Thanks