Intelligent coordination between PON and FTTR: the pathway from gigabit to 10-gigabit

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Outline

1 Backgroud

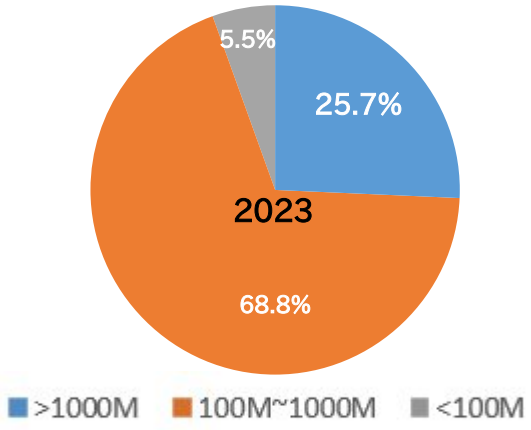
2 Requirements of 10-gigabit broadband

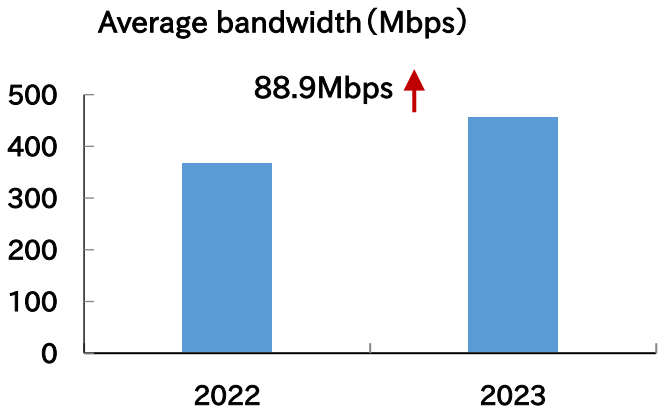
3 Coordination of PON and FTTR

Fixed broadband development in China

With the rapidly increasing of Gigabit optical access networks and users, the proportion of broadband customers with 1000+ Mbps reaches 25.7%

Gigabit broadband customers: 163 million (25.7%), over 10% incresing in 2023





- Average purchased bandwidth: **456.5 Mbps,** 88.9Mbps higher compared to 2022 (Source: MIIT)

China Moblie

>300 million
Broadband users until Jan.2024

>90 million
Gigabit users until the end of 2023

➢ **10-gigabit optical broadband era will arrive in the near future!**

10-gigabit services

p With the rapid development of new services, optical access network abilities of 10-gigabit bandwidth, low latency and network slicing are necessary

New services and experiences

2D video ☾ 3D video

1D/2D sensing ☾ 3D sensing

No interaction ☾ Full scene interaction

New architecture and requirements

large bandwidth

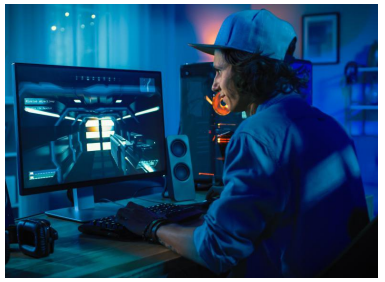
low latency

network slicing

HD live streaming/XR metaverse

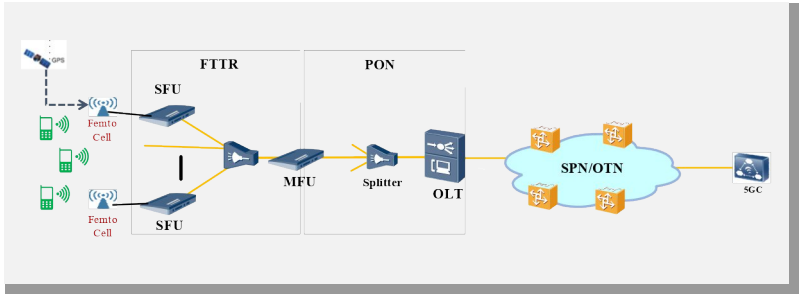
Resolution	4K	8K	XR
Bandwidth	≥50Mbps	≥200Mbps	≥180Mbps
Latency	≤50ms	≤20ms	≤10ms

Online cloud storage/gaming



Service	Multimedia Netdisk	Resolution:3840*2160 Frame rate:60
Bandwidth	≥500Mbps	≥600Mbps
Latency	≤20ms	≤10ms

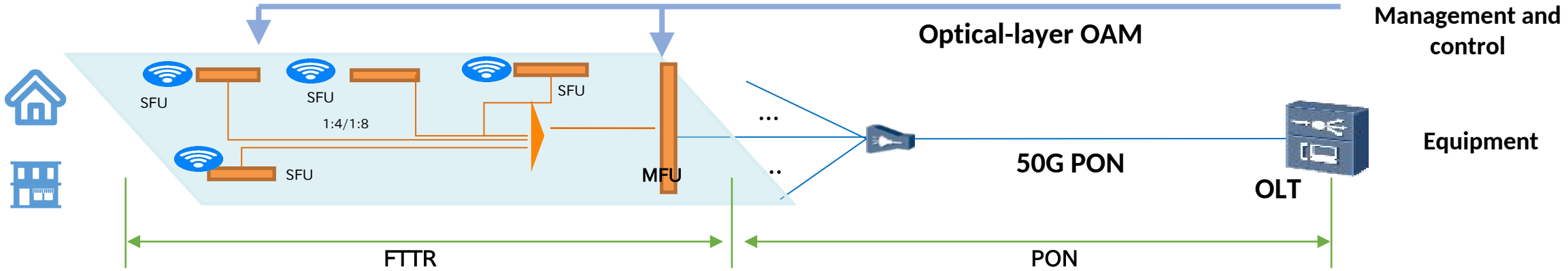
5G femto cell backhaul



Station type	4T4R
Peak Bandwidth	2.8 Gbps
Latency	<350us
Time synchronization	±50ns

10-gigabit optical access network

p Based on 50G PON+FTTR+WiFi7 to construct 10-gigabit networks with end-to-end netwok slicing to guaranttee the user experience



1 50G PON

- Speeding up of 10-gigabit optical broad-band network: 10G PON -> 50G PON
- Accelerating 50G PON industry maturity

2 FTTR

- Fiber extended to the rooms: 10-gigabit to home->gigabit to 10-gigabit to room
- OAM mechanism of PON extended to room, end-to-end centralized management and control

3 Intelligent coordination

- Collaborative networking of PON and FTTR, end-to-end network slicing
- WiFi networking based on scheduling

Features and standards of 50G PON

- As the optical basis of next generation of optical access system, except bandwidth increase, 50G PON also provides low latency and network slicing
- By far, the global standards of 50G PON is completed, the equipment is under development

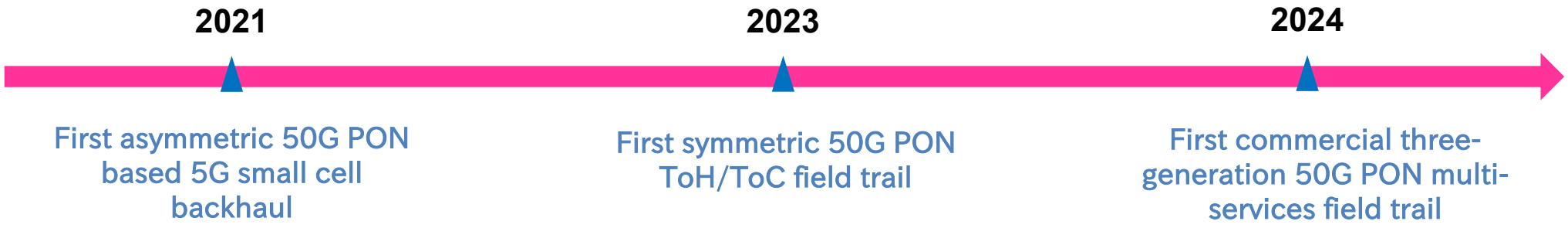
Require-ments of 50G PON for CMCC

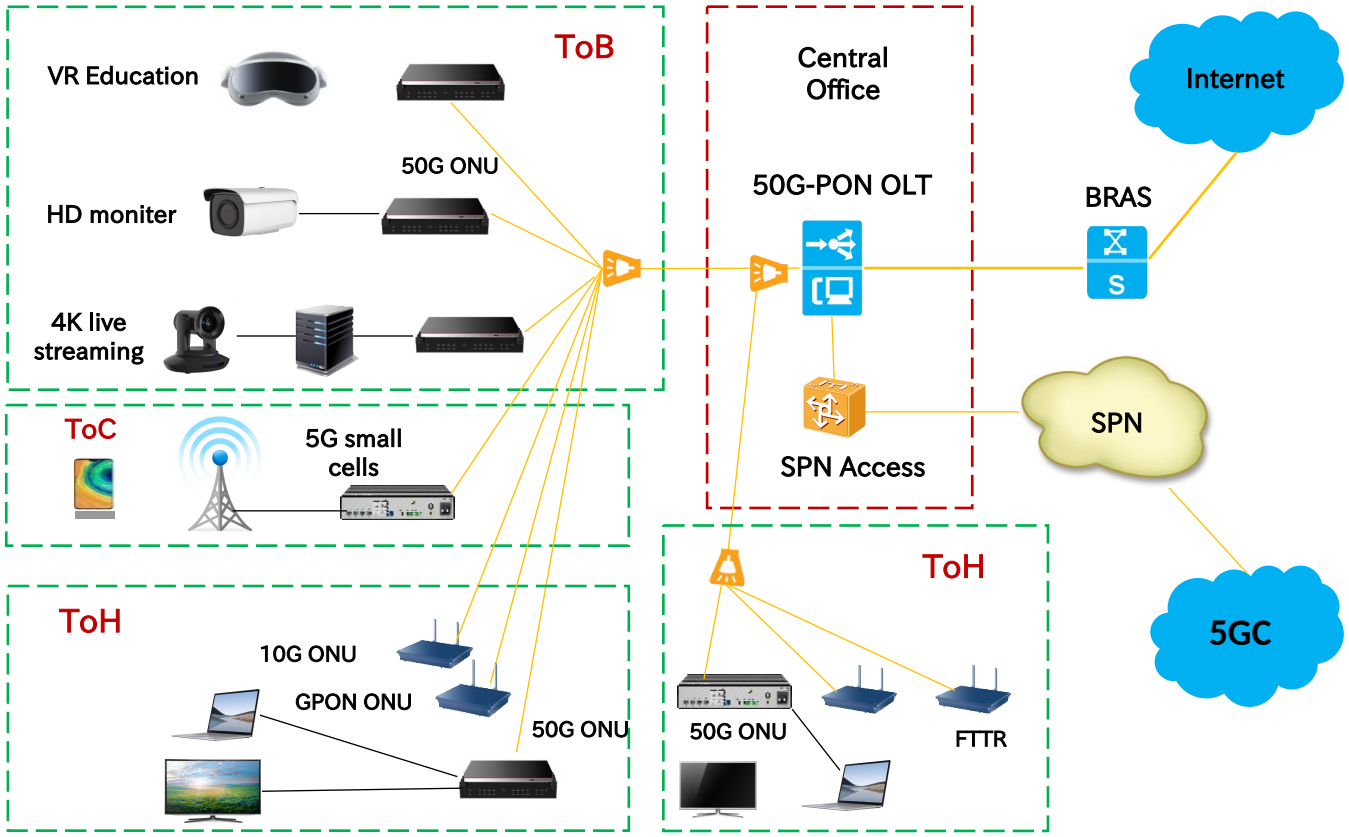
High bandwidth	Low latency	Network slicing
• Over x4 bandwidth per PON port • 50Gb/s in DS, 25/50Gb/s in US	• To satisfy the requirement of time-sensitive scenarios • PON latency: <350us	• Support differentiated services using PON slicing • Guaranteed performances for high-level services

G.9804 Series

General	G.9804.1	G.9804.1 Amd.1	G.9804.1 Amd.2
		Flex-FEC in upstream	Multiple upstream linerate
PMD Layer	G.9804.3	G.9804.3 Amd.1	G.9804.3 Amd.2
		Three-generation Combo	Symmetric class C+ power budget
TC Layer	G.9804.2	G.9804.2 Amd.1	
		DAW, optional LDPC FEC	

Recent progress of 50G PON techniques of CMCC





Fist three-generation full-linerate 50G PON based ToB/ToC/ToH multi-services field trail in CMCC Hebei province

Bandwidth

- ✓ Service bandwidth in both direction: 40Gb/s

Coexistence

- ✓ MPM coexistence with GPON and 10G PON on the field

Power budget

- ✓ Support class C+ power budget
- ✓ 1:64 split ratio and 20km fiber transmission

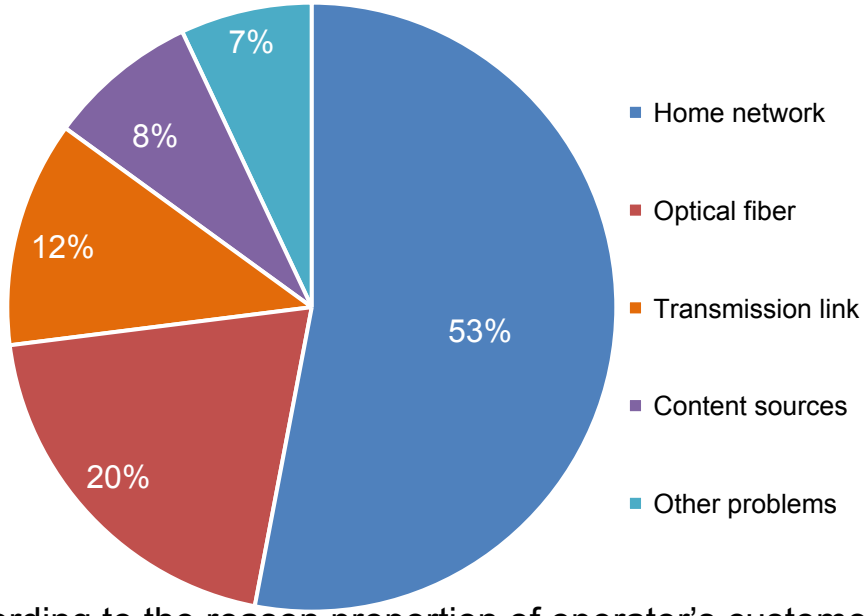
Latency

- ✓ Average latency in upstrem direction: <200us

Requirements of FTTR

- Challenges: Issues impacting on customers QoE mostly occurs in the last 100 meters.
- Requirements: To build end-to-end Gigabit to 10-gigabit optical network reaching rooms and meanwhile extend optical access network ability with cooperative Wi-Fi networking.

With 50G PON alone cannot guaranttee the 10-gigabit experience of broadband user



According to the reason proportion of operator's customer reports: 53% of the reports are related with the **quality of home networks** (source: MIIT)

Optical infrastructure extention from FTTH to FTTR

- Gigabit to 10-gigabit seamless coverage extended to the rooms
- Optical-layer OAM mechanism of PON extended to the rooms

Coordinated networking to Improve customer experience

- Collaborative networking of PON and FTTR, end-to-end slicing
- Collaboration between optical link and Wi-Fi

Intelligent coordination between PON and FTTR

p For high-value services, PON+FTTR intelligent collaboration is needed to be promoted to achieve an E2E network slicing

PON and FTTR collaboration

Optical link and Wi-Fi collaboration

Use cases

- Supports remote management for both MFU and SFU once the optical fiber is connected
- Establish third-party higher layer management system to control the entire network
- SFU authentication at the OLT side, to make the access section and home section more secure

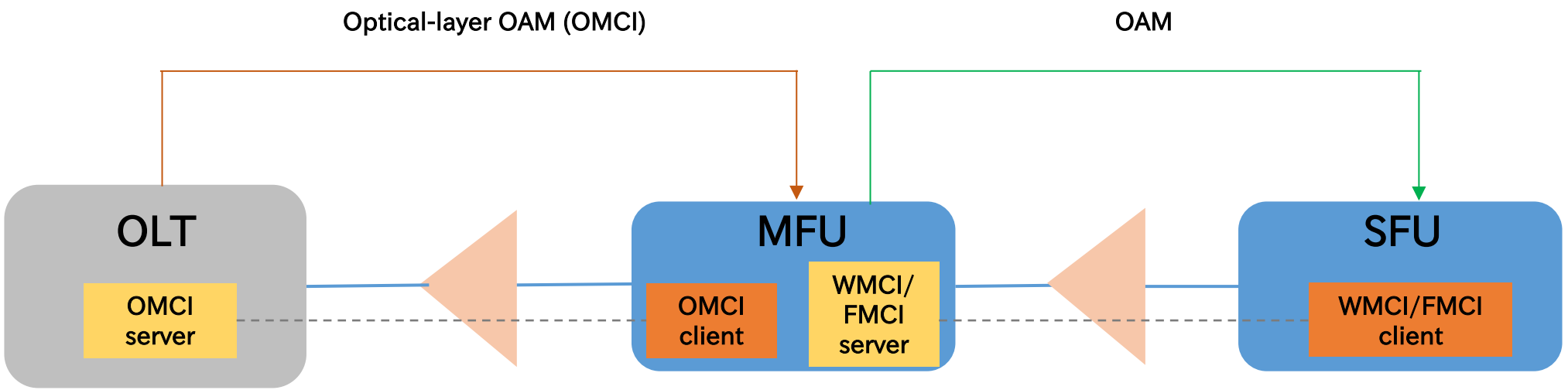
- Discover network topology from access section to home network section
- Diagnose and locate network problems from access section to home section
- Establish a remote management channel with higher priority

New approach: remote management

- OMCI server in the OLT to manage both the MFUs and the SFUs

- ✓ More reliable and real-time management
- ✓ Reuse of the management model and MEs of the ONU

Option 1: Independent OAMs in cascaded PtMP



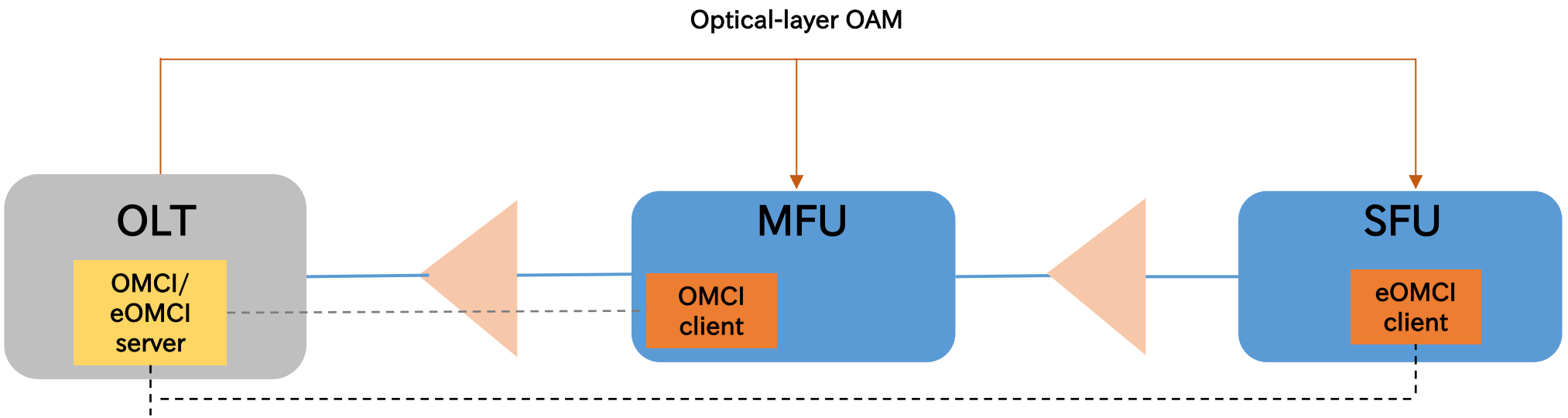
Principle

- MFU performs as an OMCI proxy to manage SFUs.
- The access segment uses OMCI between the OLT server and the MFU client.
- The home segment uses the WMCI together with FMCI between the MFU server and the SFU client.

Discussion

- Lots of additional MEs required to support the management of the entire FTTR network by the OLT
- The interoperability of OMCI in the access segment cannot directly applied to the FTTR segment

Option 2: Extended OMCI using centralized optical-layer OAM



Principle

Extended OAM channel is composed of both OLT-MFU and MFU-SFU segments

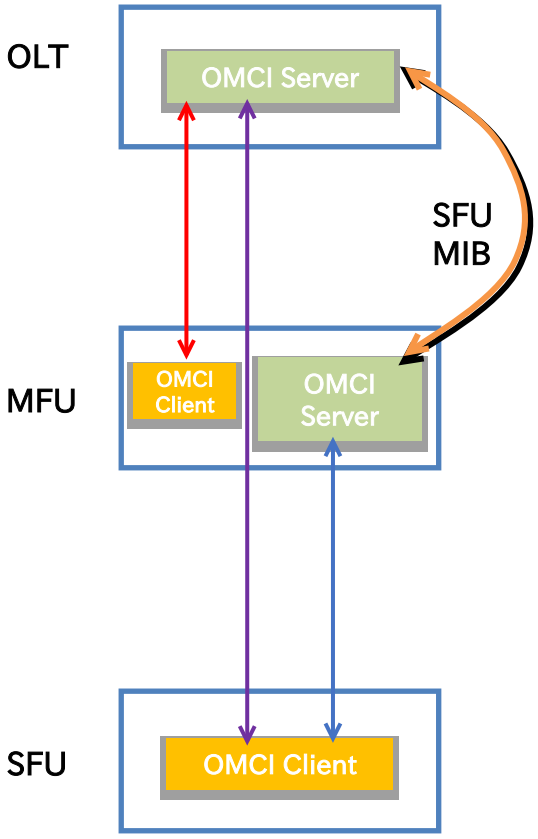
- Maximumly reuse of the PON optical-link management channel, such as OMCC and MEs
- Isolated from data channel and has the highest priority

Discussion

- Take the advantages of existing management model and MEs of the ONU
- Simplify the logical functions of the MFU since the message is directly pass to the SFUs
- Improve the interoperability between OLT and FTTR

Progress of FTTR based on extended OMCI

- Prototype supporting optical-layer OAM was demonstrated in 2022, and relevant standard items have been initiated in CCSA and ITU-T SG15 Q2/Q3 by 2023
- Call for accelerating the progress of optical-layer OAM solution and standards



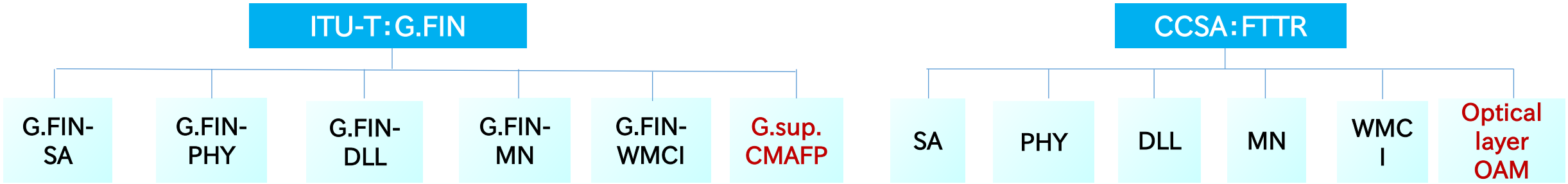
Technology	Industry	Standard
• Propose the concept of optical-layer OAM • Optical-layer OAM architecture and interface protocols are basically completed in enterprise standard • Further enrich the interface functions	• The interoperability of eOMCI protocol was basically realized between FTTR and OLT • In 2023, completed precommercial trials in 3 provinces and small-scale deployment: **Nokia, Huawei, ZTE, Fiberhome**	• Optical layer OAM standard started in ITU-T and CCSA • Accelerate the progress of optical-layer OAM solution and standards

2022
2023
2024

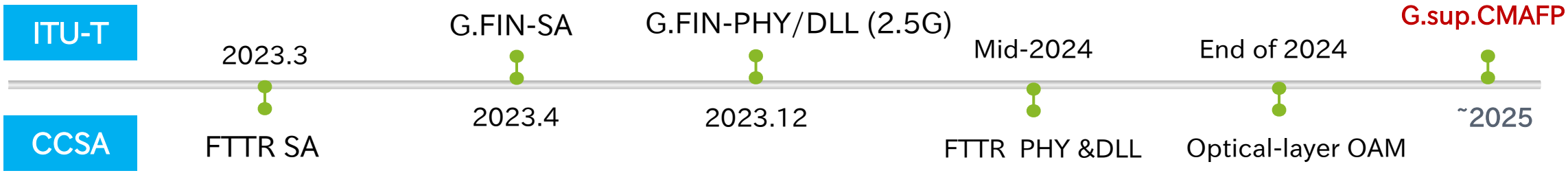
[1] Dechao Zhang, Jinglong Zhu, et al., Fiber-to-the-Room (FTTR): A Key Technology for F5G and Beyond, vol.15 issue.9, JOCN 2023
[2] Jinglong Zhu, Junwei Li, et al., First Field Trial of FTTR Based on Native Management and Control Architecture for 5G Small Cell Backhaul, OFC 2023, Paper W2A.13

Progress of FTTR standards

- The FTTR standard system in both ITU-T and CCSA has been established and achieved significant progress
- G.sup.CMAFP (coordinated management of access and fibre in premises networks) was initiated in Q2/Q3 SG15, to investigate the unified management of PON and FTTR



- G. FIN-SA, G. FIN-PHY and G. FIN-DLL(2.5G) have been approved



Conclusion

- Coordinated 50G PON+FTTR is the technical framework of next generation optical access network, which can realize end-to-end network slicing and guaranteed experience of gigabit to 10-gigabit services.

- The standardization and technology development of coordinated PON and FTTR using optical layer OAM is desirable, as well as the investigation of use cases and technical requirements.

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Thank you!