Progress on 10-Gigabit Optical Broadband Based on 50G PON and FTTR

Ning Wang
China Mobile Research Institute

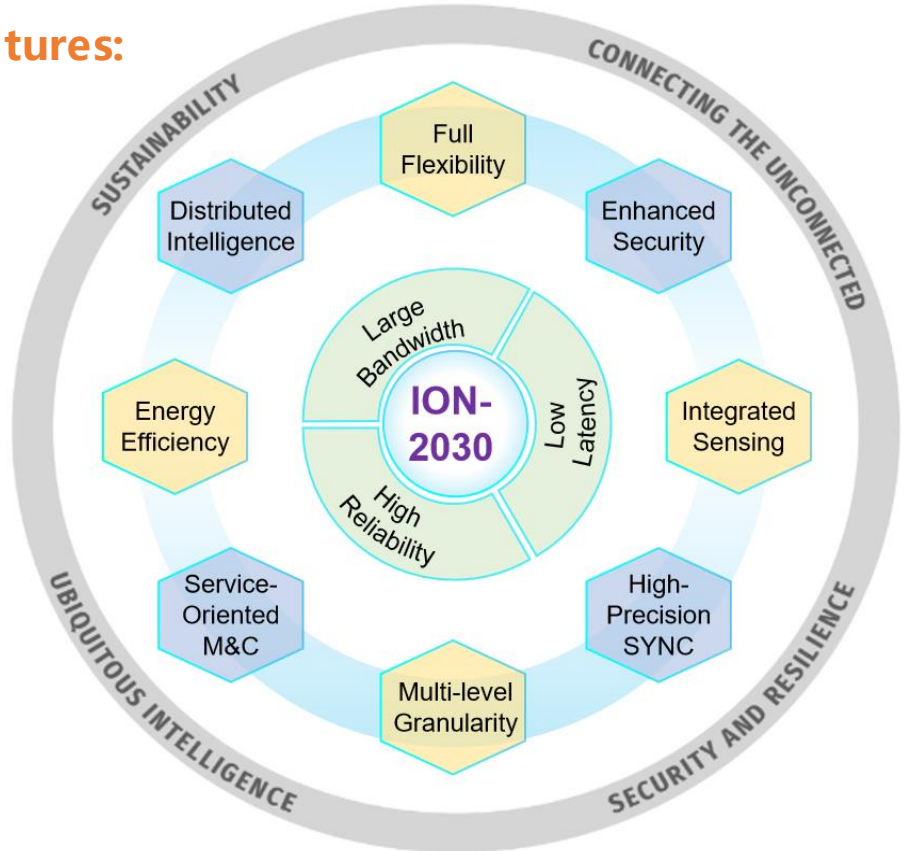
Outline

Development of optical broadband in CMCC

100-Megabit	Gigabit	10-Gigabit
2009-2016	2016+	2025+
ODN construction since 2009		
GPON construction • Choose GPON to build optical broadband networks	**10G PON massive deoplyment** • Switch to 10G PON deployment completely since 2021 • Over **490 million** gigabit coverage	**50G PON deployment** • **First field trial of 3-generation coexistence 50G PON+FTTR in 2024**
Home gateway • FTTH develop rapidly • Mainly SFU/HGU devices	**Intelligent gateway/FTTR** • Proportion of 10G gateway exceed 50% • Number of FTTR user **exceed 10 million**	**50G PON gateway/FTTR** • FTTR support symmetric 10G • Support 50G/10G Combo
Wi-Fi 4/5 • Wi-Fi 4/5 for **100Mb/s services**	**Wi-Fi 6** • Mainly Wi-Fi 6 with **1Gb/s air interface**	**Wi-Fi 7** • **2Gb/s and above** services using Wi-Fi 7

Developing trend: ION-2030 for next generation optical networks

Features:



Bandwidth

10Gb/s and beyond access capability per user

Latency

Deterministic low latency to support cloud VR, industry control...

Reliability

Network slicing, hard isolation, and end-to-end protection

Key technologies

Ultra large bandwidth:

- VHSP supports a service capacity of at least 200Gb/s
- Evolution of FTTR and Wi-Fi speed

Multi-dimensional sensing:

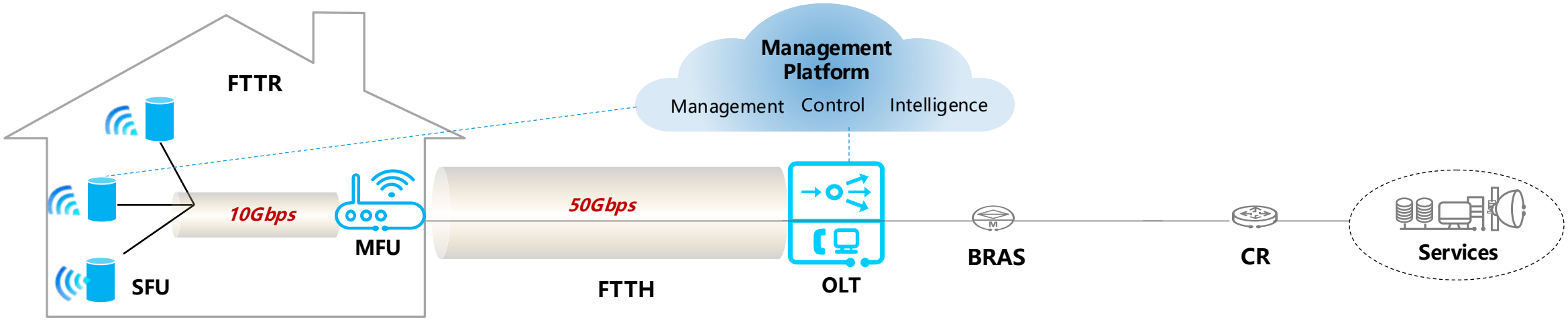
- To support ODN fault diagnosis, environmental sensing
- Li-dar (cloud point information), camera (vision information) leveraged by Wi-Fi

Coordinated management:

- MFU as the central management element, can forward management and configuration information of SFUs from OLT

Technical trends of 10-gigabit optical broadband

Construct next generation optical access network based on coordinated 50G PON+FTTR, to improve the network bandwidth, latency, coverage and network slicing capablilities



50G PON

- Evolution from 10G PON to 50G PON technology
- Accelerate the industrial maturity of 50G PON

FTTR

- Evolution from 2.5G FTTR to sym-metric 10G FTTR
- Evolution from Wi-Fi6 to Wi-Fi7
- Promote both standardization and industrial maturity

Coordinated PON+FTTR

- PON+FTTR end-to-end central management and control
- Novel PON+FTTR+Wi-Fi integrated sensing architecture to support new services

Outline

Overall progress of 50G PON

ITU-T Standards

- **2016.2** — ITU-T started study of HSP
- **2018.2** — 50G PON ITU-T stardardization initiated
- **2021.4** — First 50G PON G.9804 series consented
- **2022.9** — Define class N1 G.9804.3 Amd.1, 3-gen coexistence wavelength
- **2024.3** — Symmetric class C+ G.9804.3 Amd.2 consented

Industry progress

Chip

Module

System

Type of MAC

- ✓ OLT side: mainly ASIC
- ✓ ONU side: from FPGA to ASIC

FEC en/decoder

- ✓ standard LDPC (17280, 14592)
- ✓ Improve the BER limit to 2E-2

Type of optical module

- ✓ Mainly QSFP type, supports three generation coexistence

Power budget

- ✓ Asymmetric system: Class C+ 32dB
- ✓ Symmetric system: some vendor already reach Class C+a

Combo mode

- ✓ OLT side: support three generation coexistence in same port
- ✓ ONU side: no 10G/50G Combo yet

OLT platform

- ✓ New 10-gigabit platform are released with higher linecard bandwidth

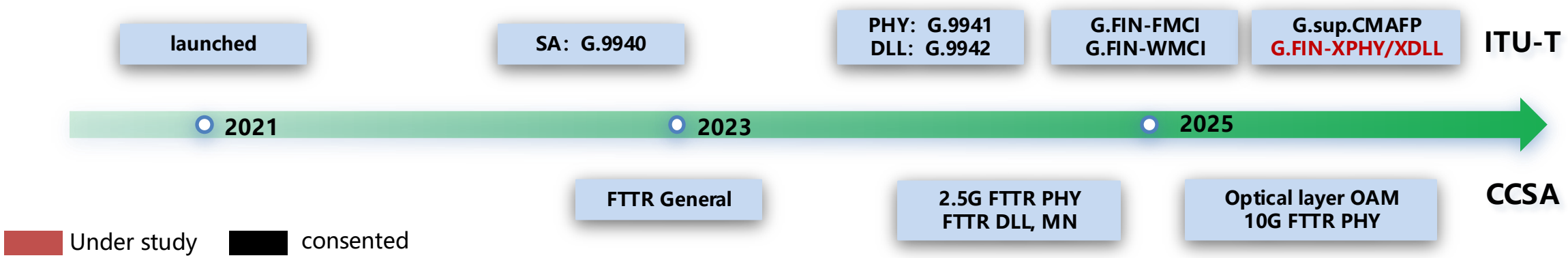
Recent progress of 50G PON system characteristics

- Serveral vendors has released **ASIC based 50G PON** equipment, system performances were effectively improved，but some characteristics like **uplink throughputs in multi-bursts per frame** case still need to be improved

	Past		Now
Throughput	L2 throughput in both directions: **~35Gb/s**	**Using ASIC for MAC**	L2 throughput in both directions: **~40Gb/s**
Latency	• Each ONU supports **4 bursts per frame** • US max latency: **>100us**		• Each ONU supports **8 bursts per frame** • US max latency: **~50us**
Power budget	Class **N1 29dB** for asymmetric and symmetric systems	**Optimizing oDSP Chip**	Class **C+ 32dB** for asymmetric and symmetric systems
Type of pluggable module	**QSFP** 8 ports per linecard		**SFP-DD** 16 ports per linecard

Overall progress of FTTR

Progress on standards



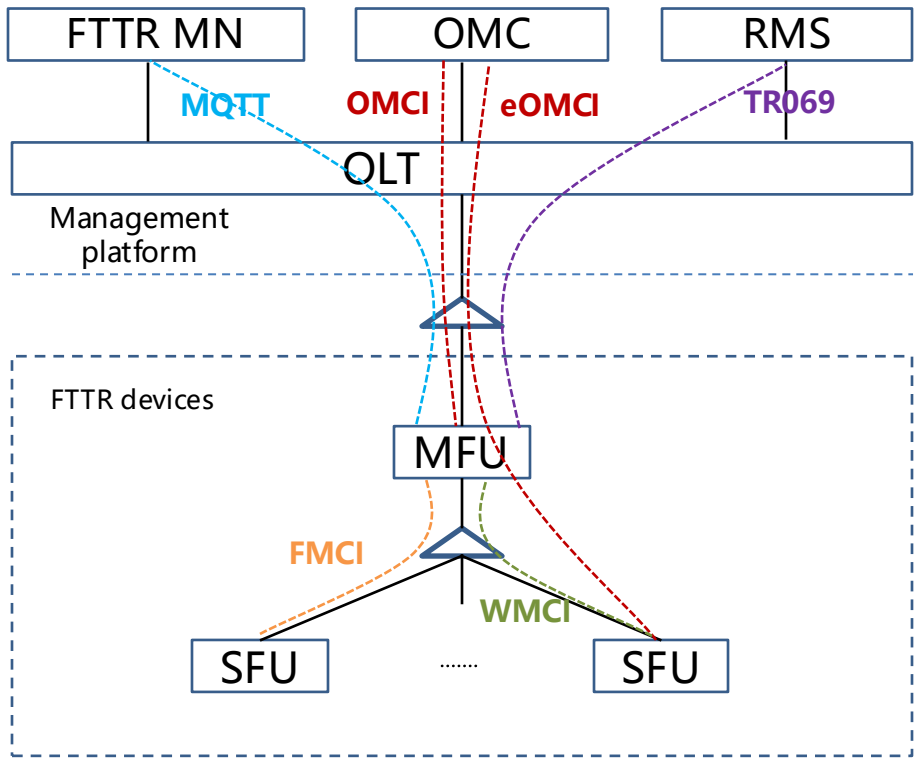
Progress on industry

	Chip	Module	System
2.5G FTTR	✓MAC type: SoC ✓Wi-Fi 6/7 type: SoC	✓PON side: 10G or 10G/2.5G Combo ✓FTTR side: symmetric 2.5G with Ra and Rb	✓ Support optical layer OAM protocals
10G FTTR	✓MAC type (PON side) : FPGA ✓MAC type (FTTR side) : ASIC ✓Wi-Fi 7 type: SoC	✓PON side: asymmetric 50G ✓FTTR side: symmetric 10G with Rb only	✓ Equipment size and performances need to be improved

Architecture of coordinated FTTR management

- Based on MQTT、TR-069 and eOMCI management protocols, to realize a centralized management and control for FTTR networks

Architecture of FTTR management



TR-069

- Reach MFU, functions are similar with traditional ONU gateway managements

eOMCI

- Expansion of OMCI, OLT can control SFUs directly, MFU can recognize and pass the SFU management messages transparently

MQTT

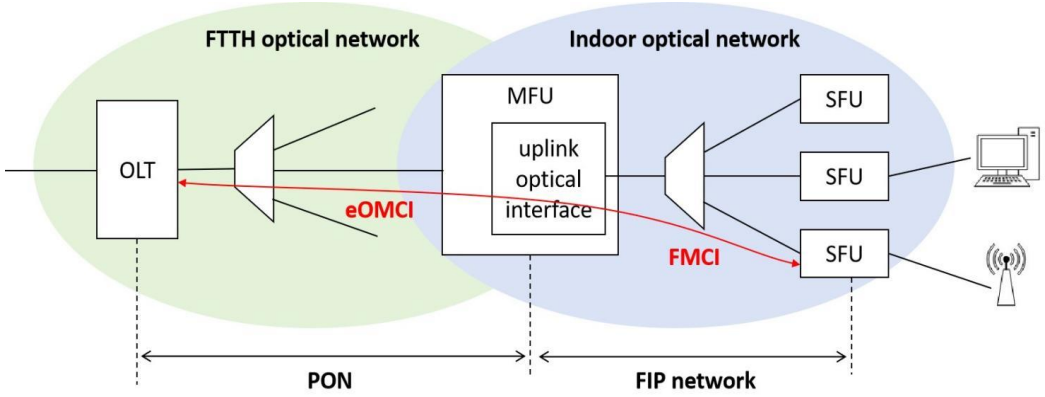
- Terminated at MFU, further manage SFUs using FMCI/WMCI
- Focus on the SFU network functions rather than optical link functions

Use cases for coordinated management

FTTR equipment authentication control

It is highly desirable that the OLT equipment can authenticate both MFU and SFU under the same PON link directly to prevent illegal MFUs and SFUs from accessing.

- Based on eOMCI and FMCI, OLT will send the management message to the SFU through MFU to activate it

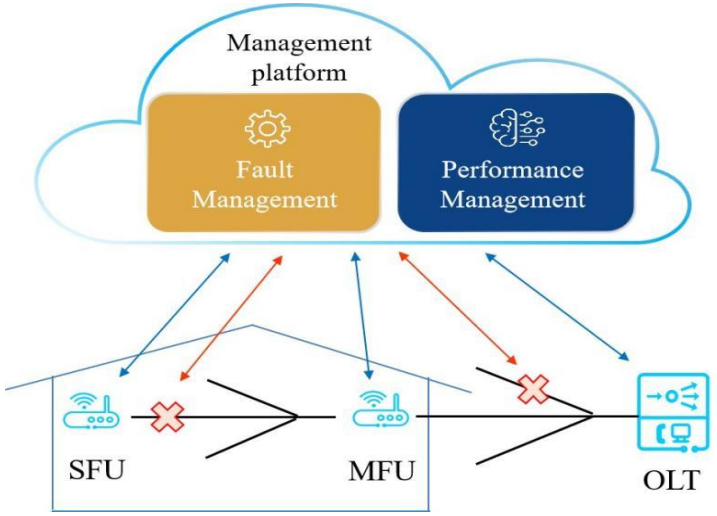


System requirements:

- The OLT could send query message to acquire SFU information used for the SFU authentication
- The OLT is capable of control the authentication of the both MFUs and SFUs under the same PON port on-demand

Performance and fault management

The temporal and spatial location information of the faults in the entire PON+FTTR system can be detected and centrally analyzed by the management platform associated with the OLT.



System requirements:

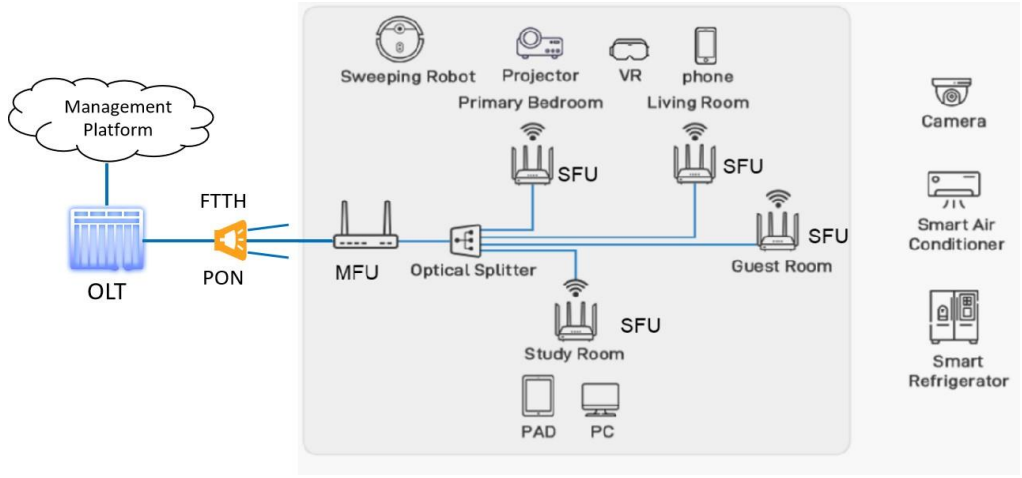
- The MFUs and SFUs should be able to periodically detect and report equipment or software failures and declare the corresponding alarms
- The OLT should be able to analyze the time and location for the faults of the entire network

Use cases for coordinated management

FTTR topology visualization

The connection topology of these devices is important for the operation and maintenance at the management platform:

- It can enhances management efficiency, simplifies planning and expansion procedure, and improves user experience



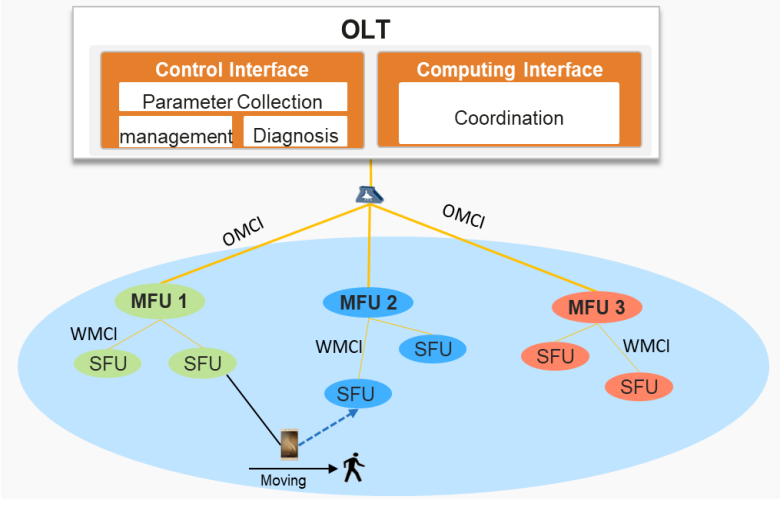
System requirements:

- The OLT should be able to send query message to MFUs, and MFUs support to respond the query with connection information, including MFU ports info, SFU ID, online status, fiber distance...
- Based on the collected information above, the OLT should be able to update the network topology and its critical indicators

Wi-Fi coordination among multiple FTTRs

Wi-Fi roaming sometimes happens when user's devices move from one FTTR network coverage area to another FTTR coverage area

By using coordinated management, the OLT can make a global coordination strategy, to adjust and optimize the network configuration



System requirements:

- The Wi-Fi operation parameters of FTTR devices can be collected and configured remotely by OLT or RMS platform
- Wi-Fi related configuration of FTTR devices is supported by eOMCI or RMS

Outline

Large scale software upgradation in car factory

Service

- A car factory in Guangzhou has nearly **2000 cars** require download and update OTA software
- Size of each file is 5GB, finished in **0.5 hour**

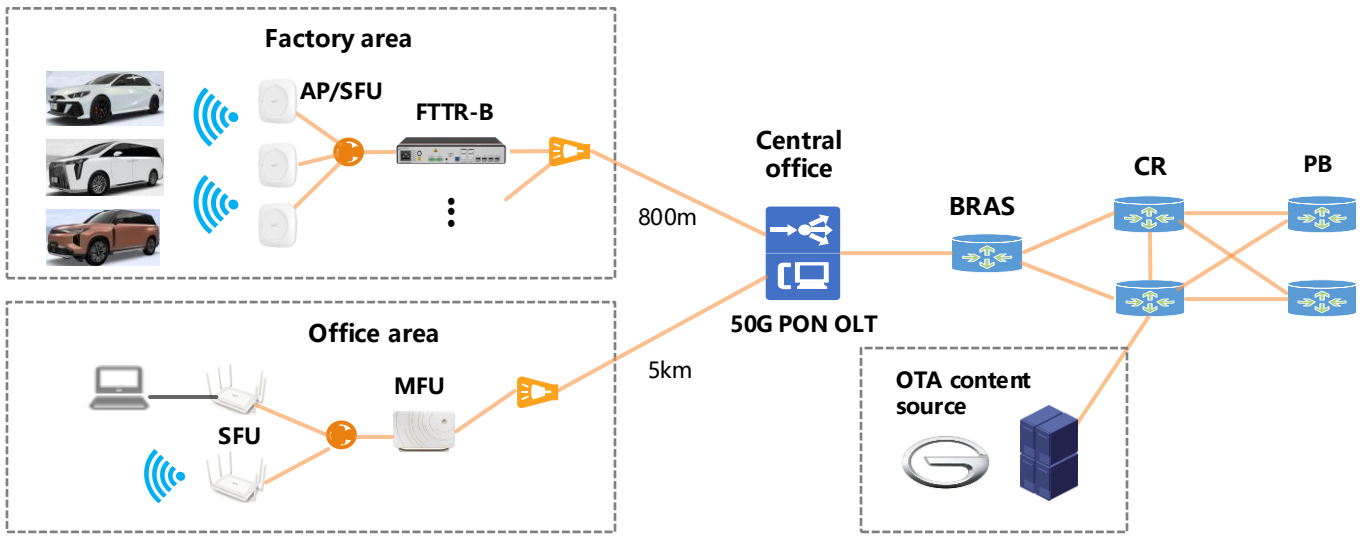
Network capability

Bandwidth: over 23Mb/s for each car, downstream bandwidth per link **exceed 20Gb/s**

Concurrency: stable download speed for 2000 cars

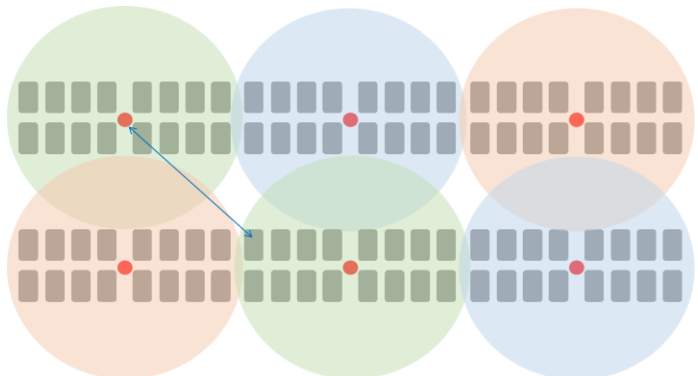
10-gigabit solution

Employing 10-gigabit optical broadband based on 50G PON+FTTR, each unit has 1 MFU and 5 SFUs, a SFU cover 16 cars, fulfill bandwidth requirement



Wi-Fi configuration

- To suppress the interference between adjacent APs, we selected Wi-Fi with different frequency（No. 35, 56, 157）



✓ SFU peak download speed: 480Mb/s
✓ MDU downstream service bandwidth reach 2.4Gb/s

Outcome：2000 cars finished their OTA software upgradation in 30 mins, with much higher efficiency

Safety improvement in digital rural area

Background: Guangxi province is dedicated to realize the modern goverance using advanced network and digital technology, aiming to improve public safety control in rural areas

Bandwidth requirements

Feature: dense HD cameras

- Single full-view camera requires a upstream bandwidth of nearly **130Mb/s**
- Upstream service bandwidth of single port exceeds **10Gb/s**

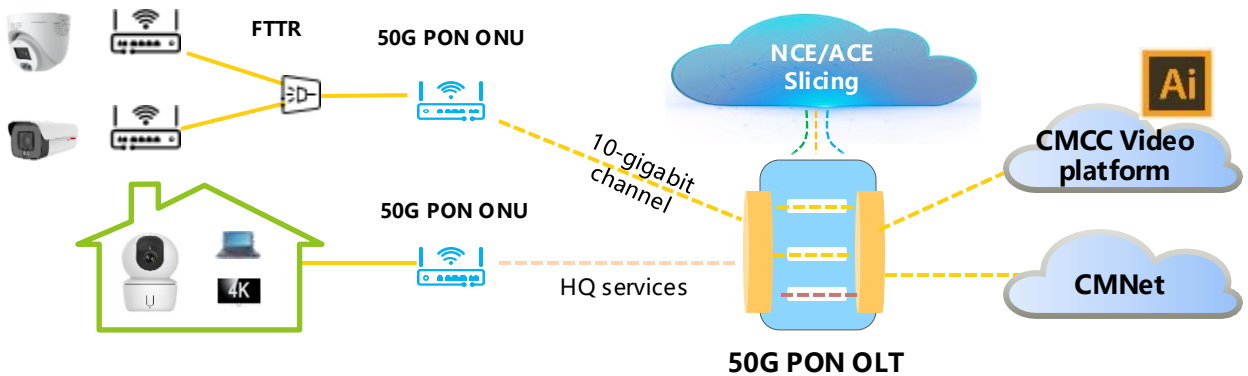
Network slicing requirement

Feature: multiple types of cameras online simultaneously

- Establish **dynamic network slicing** capability, to isolate shared camera service from existing indoor cameras
- Compatible with serveral types of video services

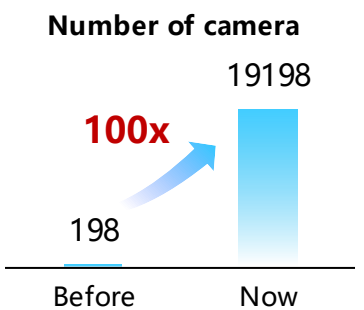
10-gigabit solution

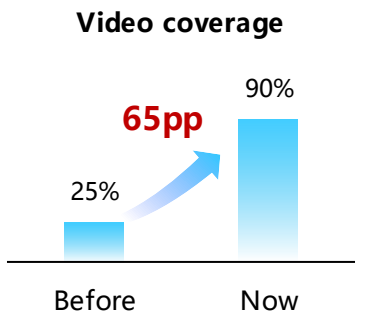
➢ **Converge outdoor shared cameras into network, based 50G PON+FTTR, to construct an intelligent 10-gigabit optical video network**



Effect

✓ Realize the digital control of rural area safety, largely improve the society management efficiency, the video coverage enhanced by 100 times compared to traditional approach





Innovative solution won the first prize of "Guanghua Cup" this year!

Conclusions

- 10-gigabit optical broadband era is coming, 50G PON and FTTR are its technical basis
- As the next generation optical access system, 50G PON has provisional realize class C+power budget in symmetric system, further endeavours are required to keep improving the system performances
- FTTR is critical for the 10-gigabit user experience, it is necessary to accelerate the technical research and standardization of 10G FTTR and coordinated management of FTTR, and by colaborating with AI, to enhance 10-gagabit service capability

中国移动 China Mobile

Thank you!