

Progress and prospects of optical network technologies and standards in China

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**China Academy of Information and
Communications Technology(CAICT)**

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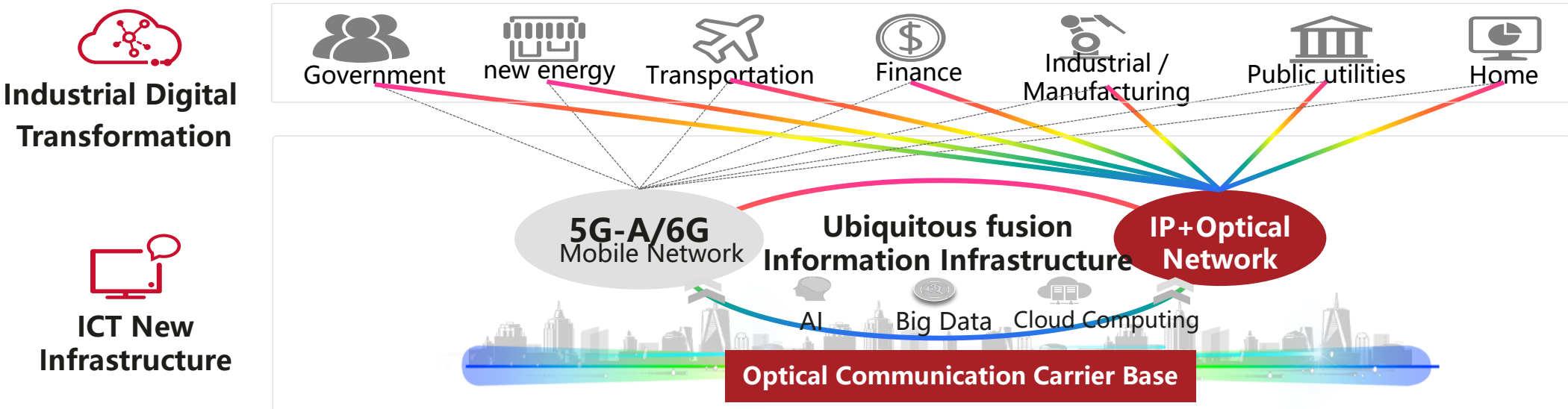
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1. Background and overview

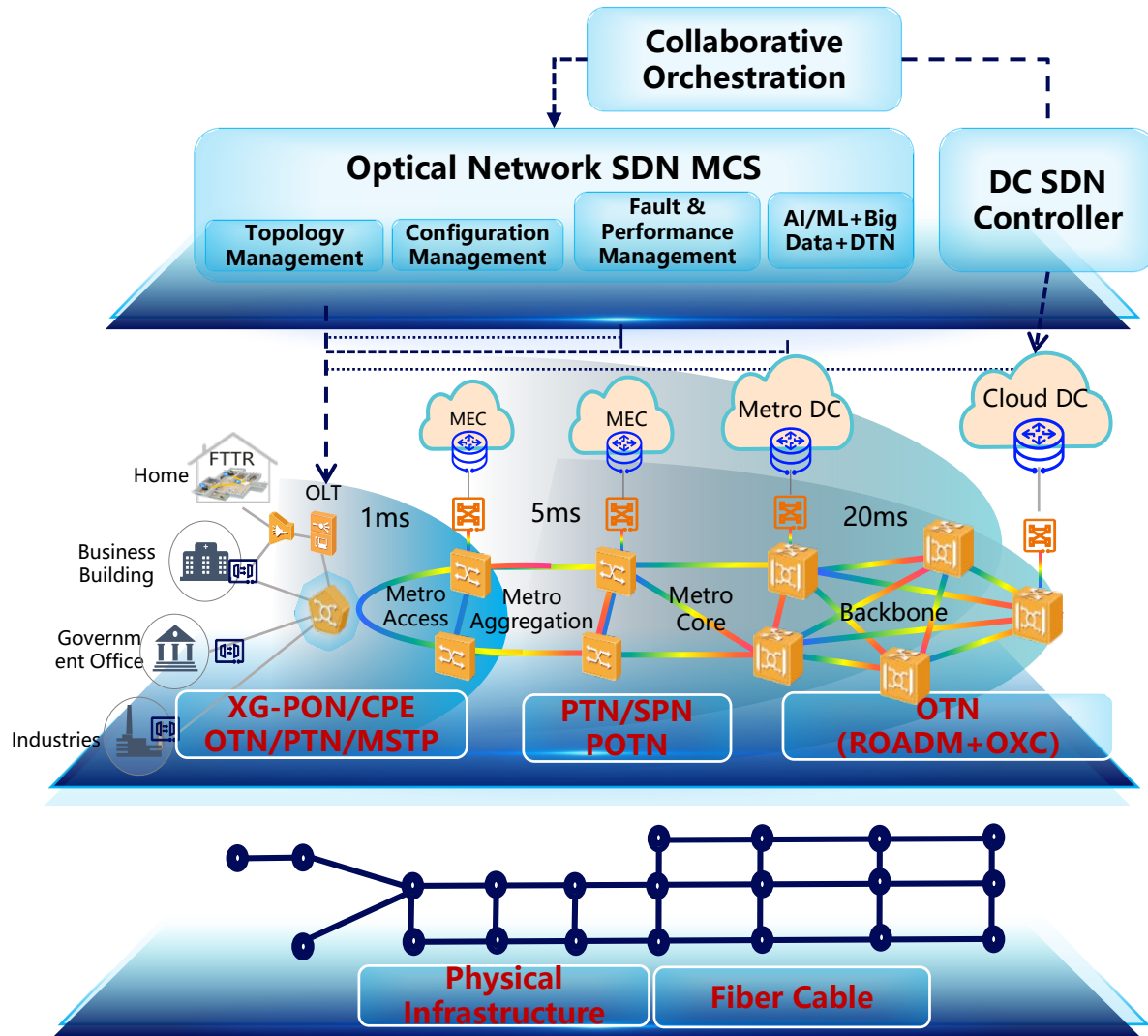
2. Progress of optical network technologies and standards

3. Prospects of future optical network

Optical networks : the cornerstone of information infrastructure **CAICT** 中国信通院



- ❑ As the cornerstone of communication networks, optical network is the key infrastructure and prerequisite for the development of **5G, data centers**, and other fields.
- ❑ Optical network plays an important role in driving effective ICT investment, promoting information consumption, and empowering various industries transformation.
- ❑ **AIGC big data** training and application, **5G-A and 6G** are the new driven factors of optical network, which will require **for 400G/800G high speed, low latency, more network capacity and intelligence SDN control** of network connections.



Optical Network Management & Control Systems

- ❑ **SDN MCS:** Enhanced MCS function and standard north & south-bound interface, current L3 of intelligent operation
- ❑ **AI/ML, Big Data, Digital Twin Network:** targeting L4 of network intelligent operation in 2025

Optical Transport and Access Network Technology

- ❑ **Backbone:** 100G/200G/**400G/800G** WDM/OTN including Flex grid ROADM+OXC
- ❑ **Metro:** 100G/**400G/800G** WDM, POTN (CTC, CMCC, CUC), PTN and SPN (CMCC), CPE OTN & PTN & SDH MSTP
- ❑ **Access:** X-PON including **50G PON, FTTR**

Optical Fiber Cable & Infrastructure

- ❑ **Fiber Cable:** G.652, **G.654E**, G.657, **SDM fiber, Hollow core fiber** etc.
- ❑ **Physical Infrastructure:** P2MP ODN, Optical junction box

CCSA' s related Technical Committees for Optical Network

TC6: Transport Network and Access Network Technical Committee

WG1: Transport Network
(Correspondence with ITU-T SG15, IEEE802.3, OIF and IETF)

WG2: Access Network and Home Network (Correspondence with ITU-T SG15 , IEEE, ETSI, ANSI, etc)

WG3: Cables (Correspondence with ITU-T SG15 , IEC TC86/SC86A)

WG4: Optical Devices
(Correspondence with ITU-T SG15 , IEC TC86/SC86B SC86C)

SWG: Special WG for Participating ITU-T SG15 meeting and activates.

TC7: Network Management and Operational Support Technical Committee

WG2: Transport, Access and Hosted Network Management
(Correspondence with ITU-T SG2 and SG15, TMF)

SP2: 5G Network End to End Slice Special Project Group

SP2 is a joint project group of TC3, TC5, TC6 and TC7, and specify **SPN slicing interworking** and SLA guarantee for 5G network.

- ❑ **TC6** is responsible for the standardization of **transport network, system and equipment, access network, transmission media** and apparatus, Television and Multimedia digital signal transfer, and so on.
- ❑ **TC7** is responsible for the standardization of **network management and maintenance, telecommunication operational support system.**
- ❑ **SP2** is responsible for the special standard project of **5G network end to end slicing, including SPN and IP RAN enhanced.**
- ❑ **TC610** is a standards promoting committee for **SDN / NFV** Technology and Industry, including **IP and optical network.**

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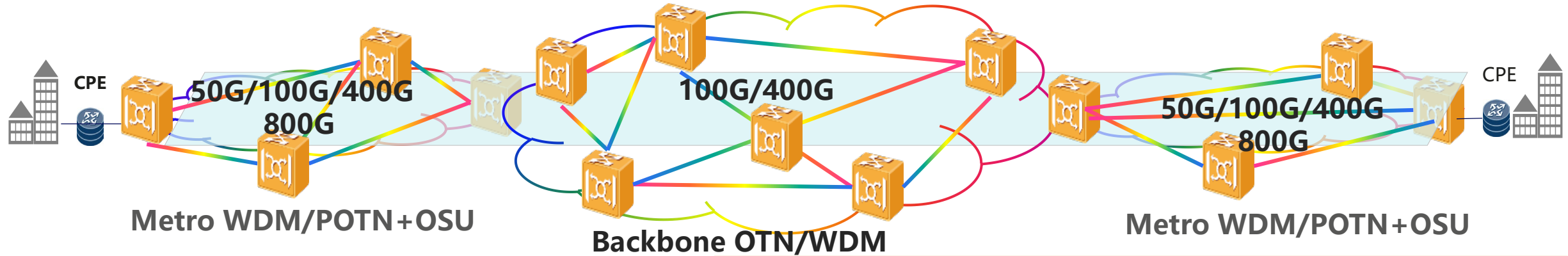
1. Background and overview

2. Progress of optical network technologies and standards

- Transport network
- Access network
- Devices and modules
- New fibers
- Network management

3. Prospects of future optical network

Chinese Operators carry out 400G WDM construction and trial operation in backbone since 2023.



China Telecom (中国电信 CHINA TELECOM)

- CNEA (Cloud Network Enlighten Application) architecture implement optical and cloud DC network integration 3.0

China Mobile (中国移动 China Mobile)

- A new architecture based on OTN/OXC optoelectronic linkage 2.0, plans to deploy 400G by the end of 2023

China Unicom (中国联通)

- A target network architecture for all-optical base, relying on the all-optical large network ROADM+OTN.

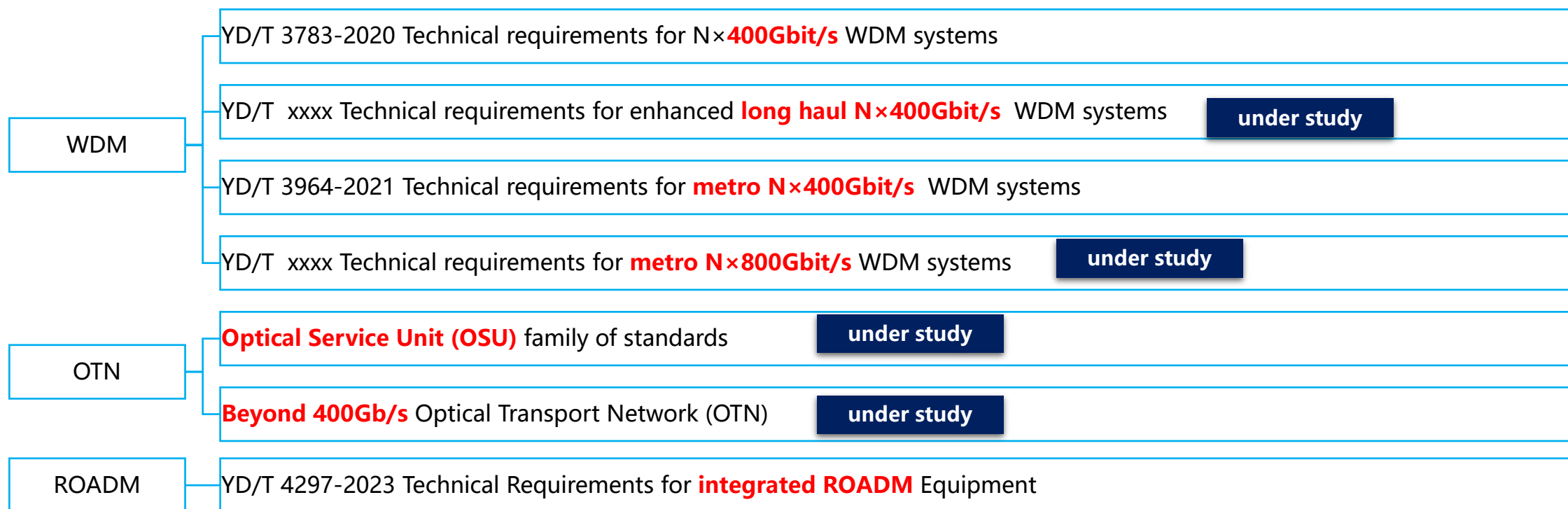
Date	Carrier	Vendor	Modulation Format	Spectrum	note
2023.1	CTC	Fiberhome	400G PCS-16QAM	16T	Field trial
2023.1	CTC	Huawei	400G PCS-16QAM	C4.8T+L4.8T	Field deployment
2023.2	CMCC	ZTE	400G QPSK	C6T+L6T	Field trial
2023.3	CMCC	Huawei	400G QPSK	C6T+L6T	Demo
2023.3	CU	Huawei	400G 16QAM	C6T	Field trial
2023.4	CU	Fiberhome	400G PCS-16QAM	C4.8T+L4.8T	Field trial
2023.5	CU	Nokia-Bell	PCS-16QAM	C4.8T+L4.8T	Field trial
2023.5	-	Fiberhome	400G QPSK	C4.8T+L4.8T	Lab test
2023.8	CU	Huawei	400G PCS-16QAM	C4.8T	Field deployment
2023.8	CMCC	Huawei、ZTE、Fiberhome	400G QPSK	C6T+L6T	Test for deployment

Domestic industry, academia, research and application institutions also focus on 800G transmission related research and experimental verification.

- ❑ **WDM:** The single carrier rate is evolving to 400Gb/s, 400G QPSK is the mainstream solution in China. Meanwhile, 800G WDM for metro applications is also in the process of standardization.
- ❑ **OTN:** Widely deployed in China. OSU, fine granularity OTN and beyond 400G OTN is under study simultaneously.
- ❑ **ROADM/OXC:** All-optical networking is the main developing direction with consensus. CCSA has published the latest ROADM equipment standard.

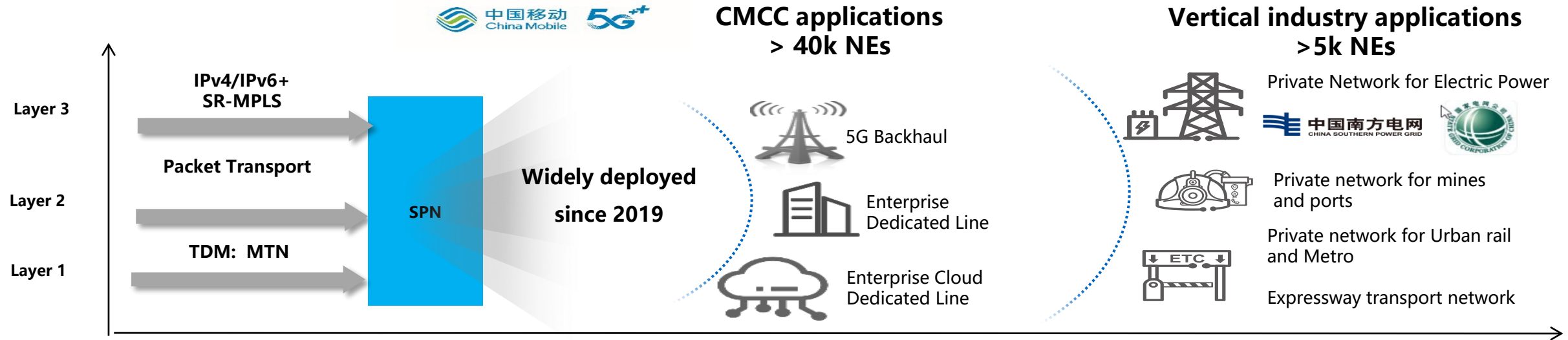


TC6 WG1



Transport network : SPN scale deployment supports 5G development **CAICT** 中国信通院

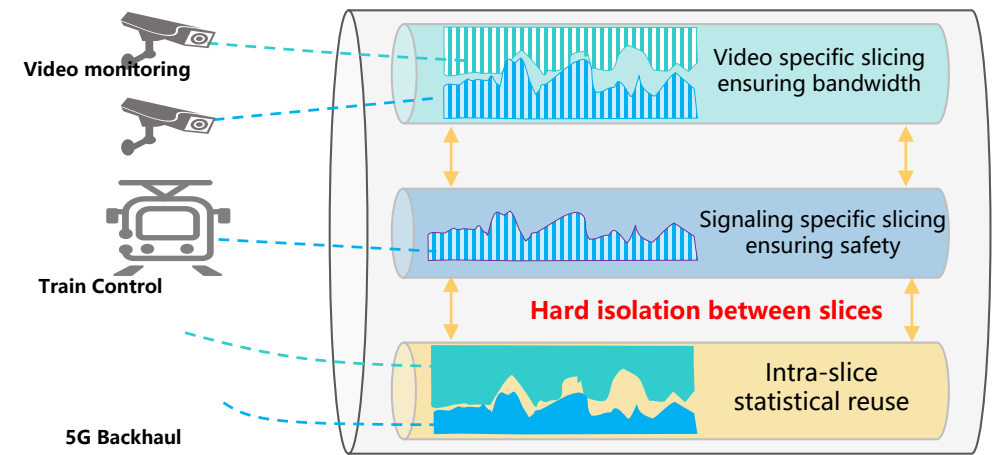
SPN technology, combined with the advantages of multi-layer transport technology, has been deployed on a large scale in fields such as 5G bearer and industry private network applications.



Main SPN Vendors

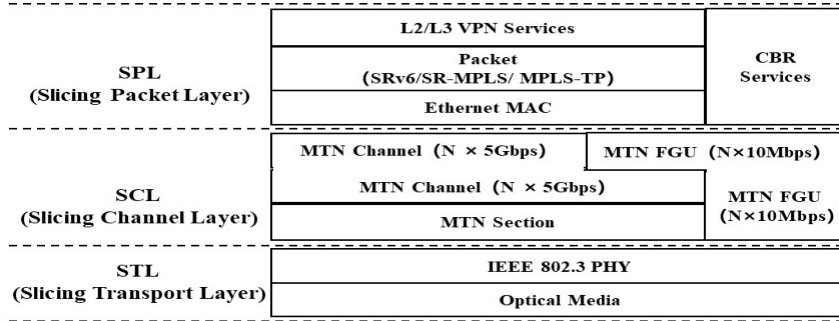


CPE SPN Vendors

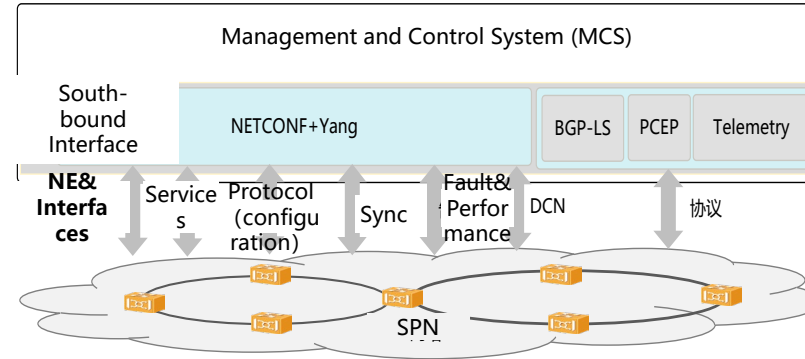


Transport network : the standardization of SPN is preliminarily completed 中国信通院

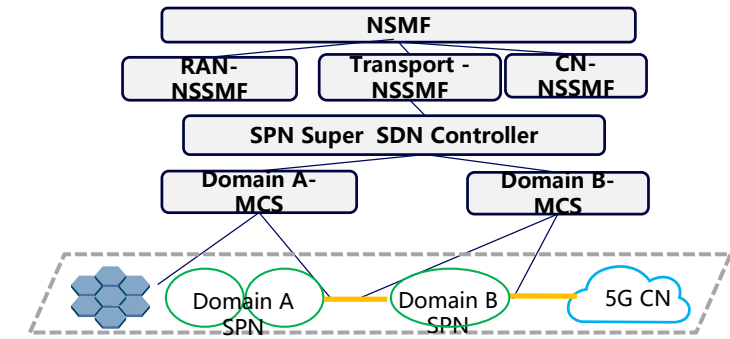
SPN Network and Equipment Architecture



SPN Management and Control Architecture



5G Network End to End Slicing Architecture



	CCSA TC6 WG1 Standards on SPN	Progress
1	YD/T 3826-2021 General Technical Requirements for Slicing Packet Network (SPN)	2021.3 Published
2	YD/T 4172-2022 Technical Requirements for Slicing Packet Network (SPN) Equipment	2022.9 Published
3	YD/T 4446-2023 Test Method of Slicing Packet Networks(SP) Equipment	2023.7 Published
4	YD/T 4372-2023 Technical Specification of South Interface of Slicing Packet Network(SP) Network	2023.7 Published
5	2021-0966T-YD Test Method of Slicing Packet Networks(SP) Equipment Southbound Interface	2023.6 Approved
6	2021-0965T-YD, Fine Granularity bearer Technical Specification for Slicing Packet Network (SPN)	2023.4 Approved
7	YDFFZT1383-2023 Test Method of Fine Granularity bearer Technical Specification for Slicing Packet Network (SPN)	2023.9 Consent
8	YDCPZT1436-2023 Technical requirements for miniaturized access Sliced Packet Network(SP) equipment	Under study

	CCSA SP2 Standards on SPN for 5G network slicing	Progress
1	YD/T 3974-2021 5G network slicing Technical requirements for end-to-end forwarding and control plane interworking based on SPN transport network	2021.12 Published
2	YD/T 4293-2023 Technical requirements for TN-NSSMF based on SPN	2023.4 Published
3	YD/T 4291-2023 Technical requirements for interface between NSMF and TN-NSSMF based on SPN	2023.4 Published
4	Test method for interface between NSMF and TN-NSSMF based on SPN	Under Study
5	Enhanced Technical Specification for 5G Network Slice SLA Assurance	Under Study

Fixed access in China had entered the era of all-optical access, and optical access services can be further extended.



The number of users with giga bps and above has been increased rapidly, with an annual growth rate more than 250%

2000M BB services base on XG/XGS-PON

More than 20 province carriers have announced 2000M broadband service.



- | | | |
|--|--|--|
| <ul style="list-style-type: none"> Shanghai Guangdong Jiangsu Zhejiang Hebei ... | <ul style="list-style-type: none"> Chongqing Hubei Tianjin Hunan Henan ... | <ul style="list-style-type: none"> Beijing Hebei Liaoning Zhejiang Sichuan ... |
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Test and field trail start for 50G-PON

Carriers look for the evolution of XG/XGS-PON targeting 5 – 10 years later



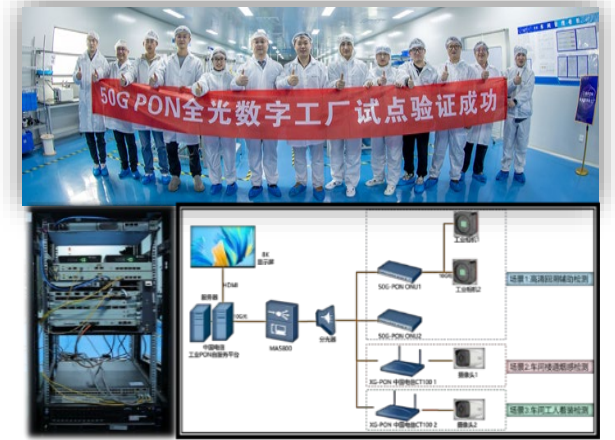
<p>Digital factory</p>	<p>CMCC-Hubei 50G-PON trail</p>	<p>CUC finished 50G-PON test and published whitepaper</p>
<p>CTC-Shanghai 50G-PON whitepaper</p>	<p>CMCC-Shanghai 50G-PON whitepaper</p>	

Progress of 50G-PON standards

- The standards of 50G-PON system requirements have basically completed.
- Next step for 50G-PON standards is for test and interoperability aspects.

Progress of 50G-PON Applications

- **Carriers network:** CTC, CMCC and CUC select 50G-PON as the evolution of XG/XGS-PON. Multiple 50G-PON trails has been executed in Chinese Carriers.
- **Industrial network:** 50G-PON has been trailed in industrial scenario.



x-PON standards progress

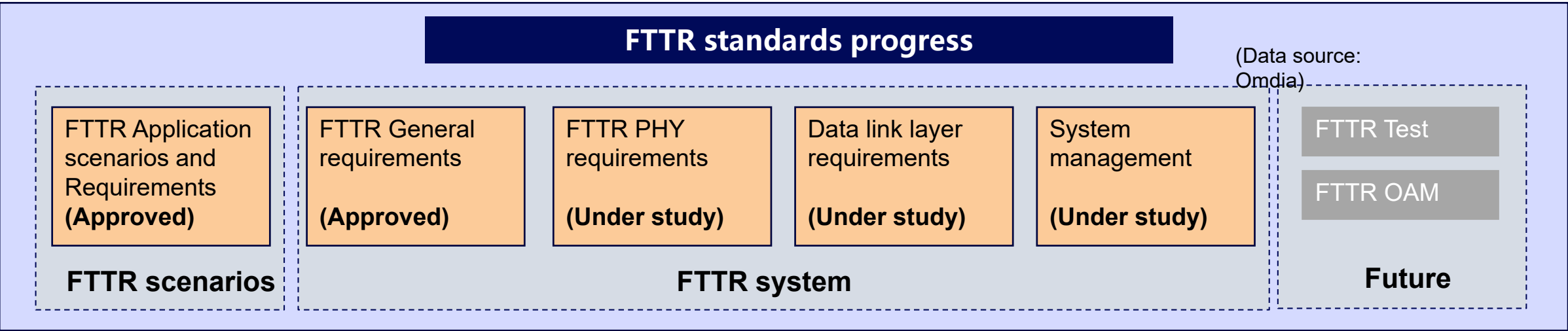
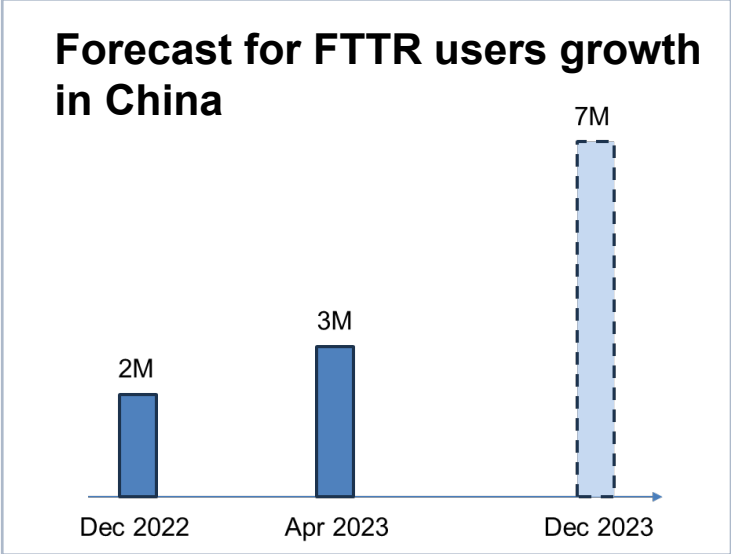
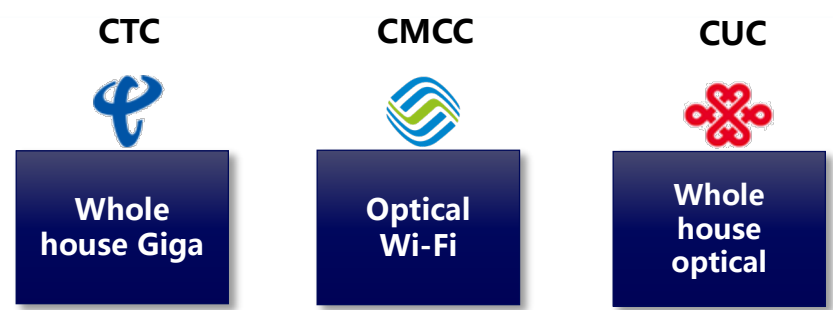
		G-PON Series	XG-PON Series	XGS-PON Series	50G-PON Series
PON system requirements	General	YD/T 1949.1-2009	YD/T 2402.1-2012	YD/T 3691.1-2020	YD/T 4300.1-2023
	PMD	YD/T 1949.2-2009	YD/T 2402.2-2012	YD/T 3691.2-2020	Approved
	DLL	YD/T 1949.3-2010	YD/T 2402.3-2012	YD/T 3691.3-2020	YD/T 4300.3-2023
Test method		YD/T 1995-2009 (2017)	YD/T 2756-2014	YD/T 3916-2021	Under study
Interoperability		YD/T 2157-2010(2017)	YD/T 3915-2021	YD/T 4115-2022	Under study

Progress of FTTR standards

- The standard of FTTR system requirements is the most hot topic in CCSA TC6/WG2.
- The standard of General requirements of FTTR has been approved in April 2023.
- The standards of PHY and DLL are expected to be approved in 2024.

Progress of FTTR Application

Operators in China have accelerated the development of higher speed optical access networks and launched FTTR service brands.



Devices and modules: Focusing on Tb/s and CPO/LPO research **CAICT** 中国信通院

800G/1.2T/1.6T

- 800G/1.2T/1.6T standards in CCSA、IEEE802.3、OIF and MSAs are under study. Industries actively develop related products.
- For 1.6T IM-DD, IEEE802.3 focus on 200G/lane scheme, 4x400G MSA focus on 100G/lane scheme, CCSA set up a series of research projects to evaluate different technical solutions.

1.6T IM-DD Module

1.2/1.6T Coherent Module

Optoelectronic Chips

1.2T/1.6T	Standard/Research report	Distance
IEEE	IEEE 802.3dj	200G/lane 500m 200G/lane 2km
4x400G MSA	/	100G/lane 100~10km+
CCSA	Research on 1.6Tb/s intensity modulation transceiver module	TBD
	Research on 1.6Tb/s phase modulation transceiver module	TBD
	Coherent driver modulator subassembly Part 3: 1.2Tb/s	—
	Technical specification of integrated intradyne coherent receiver part 6: 1.2Tb/s	—

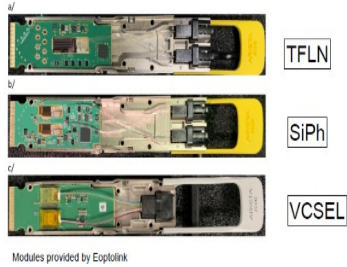
CPO

- IPEC has initiated the OIO/CPO research project in and is currently drafting a 100T+ research report.
- Key Components/Modules for Co-Packaged Optics Part 1: External Light Source Module



CCSA TC6 WG4 Research report: Research on the technology of Co-Packaged optics (2021)

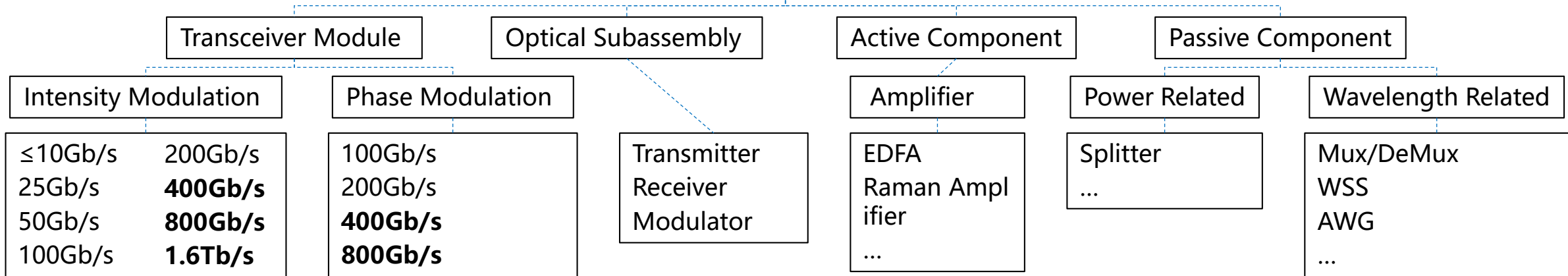
LPO



- LPO has become a new hot topic. Driven by the AI big model, LPO is expected to accelerate its landing in 2024.
- Different technical solutions are being studied.
- Standardization organizations including CCSA are considering standardization research.

Devices and modules: 400G/800G standard developed acceleratedly

Typical Classification



CCSA TC6 WG4 Standards on 800Gb/s optical devices		progress
1	YD/T 4378.2-2023 Coherent Driver Modulator assembly Part 2: 800Gb/s	2023.7 Published
2	YD/T 2799.5-2023 Technical specifications of integrated intradyne coherent receiver—Part 5: 800Gb/s	2023.7 Published
3	2021-0910T-YD Integrated Coherent Transmitter-Receiver Optical Subassembly Part3: 800Gb/s	2021.9 Approved
4	2021-0907T-YD 800Gb/s intensity modulation pluggable transceiver module Part 1: 8×100Gb/s	2021.9 Approved
5	2021-0908T-YD 800Gb/s intensity modulation pluggable transceiver module Part 2: 4×200Gb/s	2021.9 Approved
6	2022-1384T-YD 800Gb/s intensity modulation pluggable transceiver module Part 3: 2×400Gb/s FR4	2022.11 Approved
7	2021-0911T-YD Parallel active optical cable transceiver- Part 6: 800Gb/s AOC	2021.9 Approved
8	2021-0909T-YD 800Gb/s phase modulation transceiver Part 1: 1×800Gb/s	2021.9 Approved
9	Metro Application Line-side Optical Transceiver Module Part2: 800Gb/s	Under study

Multiple manufacturers launch 800G samples

- 8×100G: SR/DR8, 2xFR4/LR4
- 4×200G: DR4/FR4
- 800G: Coherent



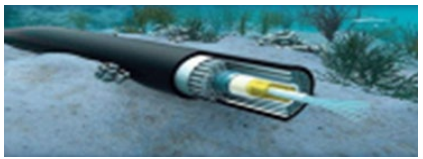
Single-mode optical fibers for telecommunication

CCSA: GB/T 9771.X	IEC: BX.X_X	ITU-T: G.65X.X
GB/T 9771.1	B1.1	G.652.B
GB/T 9771.2	B1.2 b/c/d	G.654.A/B/C/D/E
GB/T 9771.3	B1.3	G.652.D
GB/T 9771.4	B2 a/b	G.653.A/B
GB/T 9771.5	B4 c/d/e	G.655.C/D/E
GB/T 9771.6	B5	G.656
GB/T 9771.7	B6 a1/a2/b2/b3	G.657.A1/A2/B2/B3

CCSA TC6 WG3 Standards		Progress
1	GB/T 9771.1-2020 Characteristics of a dispersion unshifted single-mode optical fiber	2020.12 Published
2	GB/T 9771.2-2020 Characteristics of a cut-off wavelength shifted single-mode optical fiber	2020.6 Published
3	GB/T 9771.3-2020 Characteristics of an extended wavelength band dispersion unshifted single-mode optical fiber	2020.6 Published
4	GB/T 9771.4-2020 Characteristics of a dispersion shifted single-mode optical fiber	2020.6 Published
5	GB/T 9771.5-2020 Characteristics of a non-zero dispersion shifted single-mode optical fiber	2020.6 Published
6	GB/T 9771.6-2020 Characteristics of a fiber with non-zero dispersion for wideband optical transport	2020.6 Published
7	GB/T 9771.7-2022 Characteristics of a bending loss insensitive single-mode optical fiber	2022.6 Published

Next generation new optical fibers

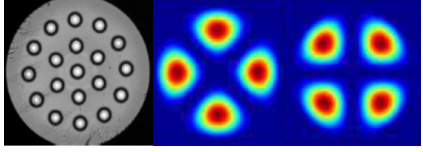
Submarine cables



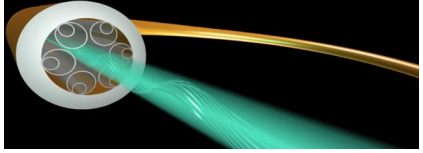
Multi-fiber optical cables



Space-division multiplexing(SDM) fibers



Hollow core fiber

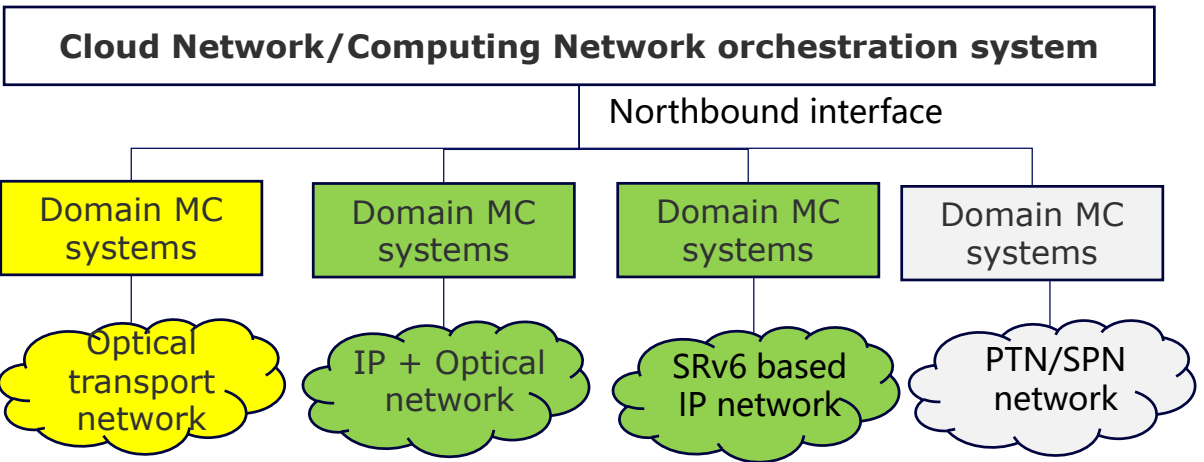


	CCSA TC6 WG3 Standards	Progress
1	Research on New Optical Fibers Oriented to Future Network Evolution	Under study
2	Research on characteristics and applications of space division multiplexing fibers	Under study
3	Technical report of hollow core fiber	Under study

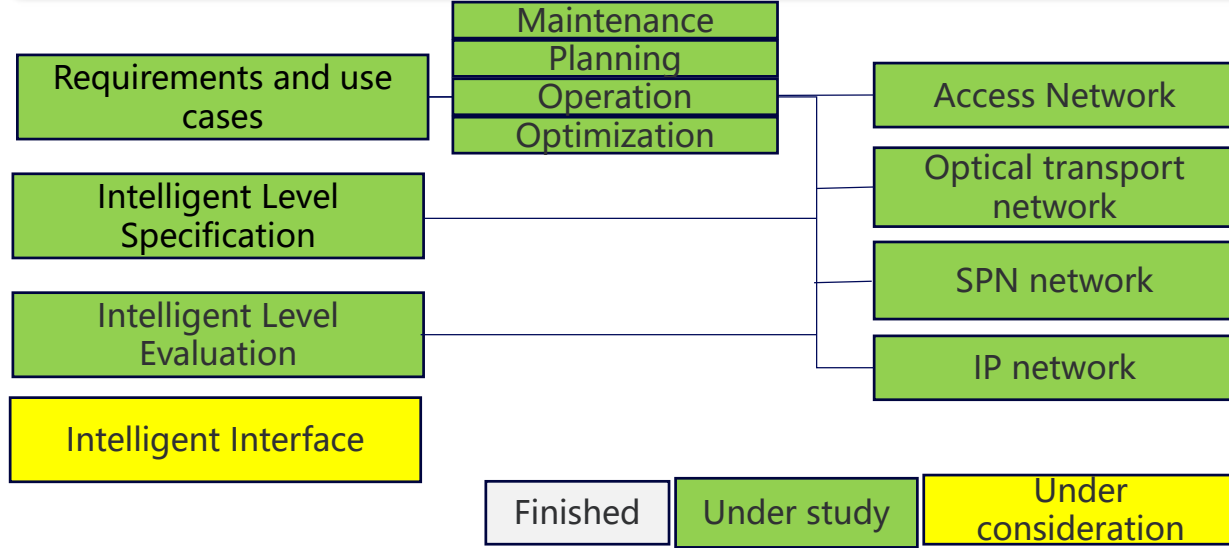
Network management: Integrating AI and DT becomes hot topic **CAICT** 中国信通院

- ❑ Mainly responsible for the research of MC systems and interfaces.
- ❑ Currently research on interface technologies for the orchestration of cloud computing and transport networks.
- ❑ Research on AI/ML application scenarios and classification technologies.
- ❑ The application of DT in transport networks has become a hot topic

MC System and Northbound Interface



Network Intelligent Operation Management



Hot Topic: Digital Twin (DT) for Transport Network

	CCSA TC7 WG2 Standards	Progress
1	Application scenarios and requirements of transport network digital twins	Under study
2	Architecture / deployment plan / test specification of transport network digital twins	Under consideration

TC610: Test specification for the level of optical network intelligent operation

- The current level of optical network intelligent operation has reached **L3+**.
- In 2025, online AI and DT based simulation functions may be introduced, evolving towards **L4**.

	CCSA TC610 Standards	Progress
1	Technical requirements/Test specification for intelligent hierarchical evaluation of cloud-optical private line scenario 1.0	Finished
2	Test specification for intelligent hierarchical evaluation of cloud-optical private line scenario 2.0	Under study
3	Technical requirements/Test specification for service experience grade evaluation of cloud-optical private line	Under study

Test cases for optical network intelligent	L1	L2	L3	L4	L5
Service creation (2022)	Manul	Tools	Fixed rules	Optimizable rules	Connect the entire process to self intelligence
Network health evaluation (2022)	Manul	Fixed rules	Configurable rules	Optimizable rules	
Alarm correlation analysis (2022)	Manul fault location	Proposal based on tools	Fixed association rules	Optimizable rules	
Optical Channel planning (2023)	Manual network planning	Planning based on tools	Planning based on fixed rule	Optimizable rules and network simulation	
Service optimization (2023)	Manual optimization	Optimization based on tools	Optimization based on fixed rule	Optimizable rules and network simulation	

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Optical networks accelerate evolution on hot technologies

B800G High Speed and Large Capacity (O+S+C+L)

All Optical Networking (OXC+ROADM)

TDM & Packet Fusion Enhancement (OSU, SPN)

End to End Network Slicing and SLA Assurance

B50G PON and FTTR for Access

High Integration (LPO/CPO/Silic on photonic integration)

Intelligent Network Management & Operating with AI/DTN

The future development of optical network need to collaborate on technological standards and application innovation research, industrial development, and intelligent network operating.

Enhance the innovation capability of all optical network

Actively exploring innovative ICT applications for optical

Building an all optical network capacity evaluation system

Global industry collaborate on optical network technology and standard innovation, enhancing industrial ecological system development for future ICT network

Thanks for your attention

