What is China doing to accelerate 5G transport network deployment?

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Since the 1980s, a new generation of revolutionary mobile communication technologies has emerged every decade. Mobile communication evolved from 1G to 4G, with a focus on people-to-people communication. In the future, 5G will become deeply integrated with technologies such as cloud computing, big data, AI, and VR/AR, shifting communications from people-to-people to people-to-machine and machine-to-machine.

The wave of investment accompanying 5G is spreading into all fields, nurturing new information products and services and reshaping traditional ICT development models. This in turn drives socioeconomic development.

5G development in China

China is prioritizing 5G technology and has issued an array of corresponding policy documents to accelerate its progress. In February 2013, China's Ministry of Industry and Information Technology (MIIT), National Development and Reform Commission (NDRC), and Ministry of Science and Technology (MOST) jointly established an IMT-2020 (5G) promotion group to accelerate 5G research and encourage international cooperation by aggregating industry, university, and research institute resources. To date, China has constructed the world's largest 5G pilot network in Huairou District, Beijing, and completed three stages of experiments with remarkable achievements.

New challenges for transport networks

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5G will bring a revolutionary service experience and new business models. However, it also imposes many new requirements on transport networks. Existing transport technical specifications, network architectures, and functions cannot meet the requirements of emerging 5G services and applications, making innovation in 5G transport evolution a priority.

Improving 5G service performance and network architecture can help fulfill new transport requirements. Compared with 4G, 5G uses wider wireless spectrums and massive MIMO, increasing peak bandwidth and experience bandwidth tenfold or more. New services, such as telemedicine and autonomous driving, require millisecond-level ultra-low latency and high reliability. To meet diverse transport requirements, 5G provides various functions, such as network slicing, flexible networking and scheduling, collaborative management and control, and high-precision synchronization. 5G promises intelligence, flexibility, efficiency, and openness, but requires transport network architecture to evolve.

Promoting 5G transport

In January 2018, the China Academy of Information and Communications Technology (CAICT) collaborated with China's big three operators – China Mobile, China Unicom, and China Telecom – and multiple network device, module and chip, and test instrument vendors, including Huawei, to jointly establish a 5G transport promotion group, which aims to advance innovation in key 5G technologies and solutions. The group has been working with industry stakeholders to develop and test 5G transport solutions. These efforts are contributing to 5G commercialization and improving China's international competitiveness in the field.

At the IMT-2020 (5G) Summit held in Shenzhen in June, 2018, the group released a white paper on 5G transport requirements. In addition to three major performance requirements – higher bandwidth, ultra-low latency, and high-precision synchronization – the white paper lists six networking and function requirements that transport networks must meet:

- **Multi-layer transport**
- **Flexible connections**
- **Hierarchical network slicing**
- **Intelligent collaborative management and control**
- **4G/5G hybrid transport**
- **Low-cost high-speed networking**

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paper on 5G transport network architecture and solutions. It summarizes the typical 5G transport network architecture and analyzes technical solutions and key technologies for the forwarding plane, for collaborative management and control, and for the time synchronization network. It also forecasts the industry's development trends in China, and proposes suggestions for the future development of 5G transport. By the end of 2018, the group is expected to release several special research achievements on management and control architecture, the 5G transport-specific optical module, and high-precision synchronization.

Key points for 5G transport development

Seeking common ground but maintaining differences to promote industry development

China Mobile, China Unicom, and China Telecom have proposed different 5G transport network solutions, including SPN, M-OTN, and IP RAN enhancement. The SPN and IP RAN enhancement solutions are based on IP/MPLS and carrier-class lightweight TDM technologies for Ethernet enhancement, helping to achieve bandwidth isolation, deterministic low latency, and network hard slicing. They aim to use one network to transport multiple services, such as 5G and private line services.

The M-OTN solution is based on traditional OTN enhancement transportation, but simplifies the OTN and enables it to meet the development trend of packet services and the low-latency requirements of 5G fronthaul, midhaul, and backhaul. This solution aims to efficiently transport 5G, private line, and other services on OTN networks.

Market requirements, industry chain robustness, and overall network costs determine whether these solutions can be widely deployed.

When developing 5G transport solutions, multiple factors must be considered, including network features, service requirements, and cost. By analyzing CRAN, 5G core network cloudification, DC-centric deployment solutions, and network support for IPv6, we have the following suggestions for the future development of 5G transport networks' forwarding plane technologies and applications:

- **5G fronthaul**

In regions with abundant fiber resources and those with low fiber deployment costs, low-cost optical fiber direct-connection solutions are preferred. For other regions, selecting a fronthaul solution by considering factors such as network costs and O&M management requirements is the best course of action.

- **5G backhaul**

The L2VPN+L3VPN or L3VPN-to-edge solution can be used for 5G transport networks that have been newly constructed or evolved from existing 4G networks.

- **IPv6 support**

Due to the shortage of IPv4 addresses, 5G transport networks must support IPv4/IPv6 dual-stack and 6vPE forwarding.

Adopting SDN-aided intelligent management and control

5G transport network architecture is changing and imbuing 5G networks with new characteristics such as network slicing, L3-to-edge deployment, and full-mesh network connections. In addition, 5G transport networks must support 4G, 5G, private line, and other types of services deployed in various modes. These impose new requirements on transport network management and control.

A 5G transport network management and control platform should provide the following functions:

- **Agile and flexible service provisioning**

Provides plug-and-play, automated planning, and fast deployment, and support minute-level, on-demand, and automated service provisioning.

- **Multi-layer and multi-domain flexible end-to-end (E2E) control**

Implements cross-layer and cross-domain service deployment and efficient O&M.

- **Network slice-based management and control**

Manages and controls slices that carry network resources to meet the network slicing requirements of the upper-layer network, which includes automated network slice deployment, slice resource isolation, service deployment on slice networks, and slice network O&M.

- **Efficient and intelligent O&M**

Provides intelligent network O&M capabilities such as service-centric intelligent troubleshooting, AI-based fault analysis, self-healing, and service performance monitoring. This allows the implementation of automatic, closed-loop, and intelligent O&M throughout the network lifecycle.

- **Compatibility with existing networks**

Gradually introduces functions, such as E2E service orchestration and intelligent O&M, to smoothly upgrade the existing network, protect existing investment, and reduce network O&M labor, complexity, and costs.

- **Unified interfaces**

Provides unified northbound interfaces (NBIs) with excellent scalability as well as southbound interfaces (SBIs) that support multiple network protocols and can be gradually opened.

Focusing on BiDi and PAM4 technologies to promote optical module industry development

5G creates huge demands for optical modules, especially modules with higher rates, longer transmission distances, wider temperature ranges, and lower costs. New techniques and technologies are required to reduce optical module costs.

For 5G transport, new 25/50/100 Gbps and Nx100/200/400 Gbps high-speed optical modules will be introduced in

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the access layer and the backhaul aggregation/core layer, respectively.

5G fronthaul fiber resources are limited, and single-fiber bidirectional (BiDi) optical modules are urgently needed. The IEEE has started developing IEEE 802.3cp as a 25/50 Gbps BiDi standard, and the CCSA in China has started developing a 25 Gbps BiDi standard. If the transmission distance is less than 80 km for midhaul and backhaul, various types of optical modules can be used, for example, 25 Gbps non-return to zero (NRZ) and 50/100/200/400 bit/s PAM4 modules. If the transmission distance is over 80 km, coherent optical modules will be mainly used. PAM4 electrical chips with high linearity have already been launched, and 25/50 GBaud lasers and detector chips with high linearity are still being developed.

Preparing transport networks for 5G

Transport networks, which provide basic pipes, must be 5G-ready before wireless networks. By the end of 2019, transport networks will undergo a key period of 5G-oriented construction. Operators need to reserve infrastructure resources, such as optical fibers, optical cables, equipment room space, and electrical power, for transport networks. They must also analyze whether their existing networks meet 5G service requirements, determine feasible solutions, and carry out pilot construction based on their own network characteristics.

Currently, multiple operators in China have completed infrastructure resource checks and have started reserving resources such as optical fibers, optical cables, and electrical power. The pilot construction of 5G transport networks is underway in many Chinese cities, including Beijing, Shanghai, Shenzhen, and Hangzhou, and the requisite technologies and solutions are being developed. In China, large-scale 5G pilot construction will likely begin in 2019 to meet 5G commercialization requirements in 2020.

Many countries and operators have started 5G trials and launched strategic plans to develop the 5G industry and seize a strategic command point. China has made a string of achievements in 5G technology R&D, testing, and industrialization. By increasing support for 5G transport R&D and innovation in the future, China hopes to continue making breakthroughs in key fields such as core chips and SDN-aided intelligent management and control. China will also promote the development of 5G standards, carry out 5G tests, and construct network infrastructure to accelerate the industrialization of 5G transport devices, chips, and test instruments. This will boost the coordinated development of 5G and 4G, laying a solid foundation for 5G commercialization as part of an innovative ecosystem.