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Strengthening advantages: Building an experience-centric converged transport network

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

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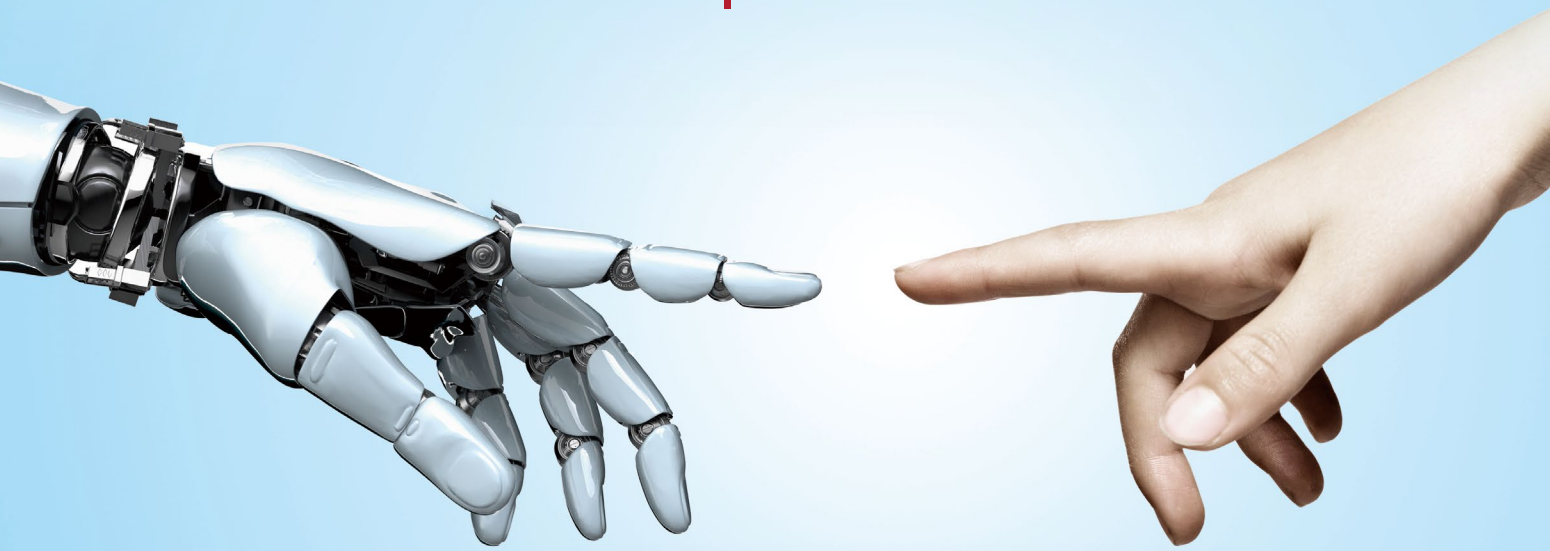

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5G will have a profound effect on the converged transport network

At the 9th Global Mobile Broadband Forum (MBBF 2018) in London on November 20, Huawei Rotating Chairman Ken Hu reported that 154 operators in 66 countries are conducting 5G tests and that the large-scale shipment of 5G devices have begun.

5G sets the stage for innovation and transformation in consumer services and vertical industries. But 5G is more than "New Radio", it will have a profound effect on converged transport network. 5G transport network requires new infrastructure rather than a new network. Operators have shifted from single services to multiple services, and are ready to build full-service operation capabilities in the 5G era.

Every generation of mobile services is accompanied by an evolution in the supporting transport network. A more powerful transport network is needed in the era of full-service operations. Generally, in the initial stages, mobile services, enterprise services, and home broadband services are deployed independently in the metro and access layer. However, in the post-4G and 5G era, the number of base stations will increase sharply. Enterprise services are accessed from a single point, and from large enterprises to SMEs. In particular, the development of home broadband services has reached a certain penetration rate, which leads to massive access requirements. If this is separately performed, investment is wasted and the flexibility and scalability of network and service access are severely restricted.

The convergence of the transport network is prerequisite as we shift from passive access and on-demand expansion to top-down design and the active coverage of valuable areas. Operators can then develop full services capabilities and retain a favorable position.

Steven Qin

Steven Qin,
President of Huawei Network Marketing Department

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Tao of Business

Compared to 3G and 4G, 5G delivers higher bandwidth, many more connections, and lower latency. Shen Gangwei, Vice GM for the Department of Planning and Technology of China Mobile Zhejiang, believes that these requirements in major service scenarios greatly impact transport networks.

GSMA forecasts that by 2025, the number of global 5G connections will reach 1.1 billion, with one-third of the world's population connected to 5G networks. As the 5G industry matures, 5G will enable the connectivity and digitalization of everything. As a result, the operator market will extend from individuals and homes to industries, an area that will integrate further with ICT.

Winners

China Telecom Shenzhen is running one of the first six 5G field trials for China Telecom. In partnership with Huawei, the operator has invested in 5G innovation and begun researching how to commercialize 5G technology.

China Unicom Beijing believes that the readiness of the transport network is critical in bringing 5G to market quickly. Therefore, infrastructure resources need to be reserved, and 5G-oriented planning and reconstruction must be completed for transport networks before the reconstruction of wireless and core networks.

Strengthening advantages: Building an experience-centric converged transport network

By Ryan Ding, Huawei Executive Director and President of Carrier BG

With the 5G era and ubiquitous connectivity now within reach, telecom operators are battling it out with industry peers and over-the-top (OTT) players to see who will be the first to supply the public with all the benefits that come with 5G.

Some traditional operators have started enhancing their full-service advantages and competitiveness by introducing IPTV and package bundling. Mobile operators, meanwhile, have been launching integrated fixed-mobile convergence (FMC) services to enhance customer loyalty and strengthen their service advantages. Full-service FMC operations have emerged as the most effective aspect of many operators' Mobile First development strategies.

Cross-industry competition from OTTs has shifted the focus of operators to services. However, operators are also facing challenges in their key area of expertise — transport networks. More OTTs, including Google, Amazon, and Alibaba, are building their own ultra-large data center (DC) nodes and backbone transmission networks, and are even expanding to cover metro networks. Leading OTTs are also developing last-mile plans to extend their networks to the access layer.

To compete with OTTs, operators must strengthen their advantages. There is a growing consensus that to achieve this, an operator needs to build a converged, flexible, and intelligent transport network that provides outstanding user experience and meets service development requirements for full-service operations.

Operators will no doubt face a series of problems and challenges during network construction. First, how do they determine the high-value areas that require preferential construction during planning? Second, how can they construct networks in a quick, efficient,

and cost-effective manner? Third, how do they ensure that O&M is efficient and automated? And fourth, how can they implement long-term future-proof evolution so as to guarantee competitiveness? Planning, construction, O&M, and evolution are interlinked and represent the main focus of most operators. Here is what we recommend:

Move fiber access points downstream to quickly access multiple services and improve competitiveness

To stay ahead of the competition, network access points must be moved downstream so they're as close to customers as possible. Specifically, integrated service access points need to be constructed based on fiber networks to form integrated service access areas that cover homes, base stations, and enterprises. This allows an immediate response to requirements and quick service provisioning.

Pinpoint high-value customers and areas with big data analytics for precise planning

Planning the exact location of a fiber access point to develop more users and services is the main concern of operators when access points are moved downstream.

To help operators identify high-value areas and users, and plan the locations of their integrated service access points, Huawei provides the SmartCAPEX analytics tool. The data this tool analyzes includes the mobile phone locations of high-value users at night, user data quota consumption, enterprise and community distribution in a specified area, and the intensity of the competition. Services can then be quickly developed based on network planning to deliver strong coverage and short-distance access in combination with the cloud-based engineering tool.

> To stay ahead of the competition, network access points must be moved downstream so they're as close to customers as possible. Specifically, integrated service access points need to be constructed based on fiber networks.

This tool and methodology have already been used by operators in a number of countries, including China, Costa Rica, Mexico, and Brazil.

Improve network construction efficiency and develop converged services by collaborating on infrastructure

After the location of an access point has been determined, the network construction phase can begin. But any number of problems could occur, including difficult site and power acquisition. Building a transport network efficiently is the second major problem facing operators. However, with its rich experience, Huawei provides a diverse range of fast network construction solutions for different scenarios.

Use base stations as anchors and reuse mobile backhaul (MBH) network resources to quickly construct networks and develop converged services

The most efficient and cost-effective network construction solution involves reusing MBH network resources by leveraging a large number of existing base stations and deploying short-distance last-mile fiber to cover nearby customers.

One operator in an area of Mexico City, for example, selected more than 20 fiber base stations according to home broadband requirements and its site resources, including site location and the availability of power supply, space, and backhaul bandwidth. It then deployed mini OLT devices inside mobile cabinets and laid out last-mile fibers within 300 meters to quickly provide fiber broadband services to the surrounding homes. The operator started receiving revenue just two months after the project was completed, shortening the payback period to less than two-and-a-half years. Another operator in Guangdong, China used its dense IP RAN networks to develop private line services for more than 1,000 high-value commercial buildings. Using its wide-coverage networks and fast service provisioning, the operator attracted hundreds of high-value private line customers in a year – a remarkable achievement.

Reuse fixed network cabinets, make them multi-purpose, and implement FMC for the rapid and low-cost deployment of mobile base stations

By reusing the existing street cabinets of a fixed network as a mobile site, an operator can quickly develop mobile services at low cost.

When developing its LTE networks, one Egyptian operator faced difficulties in site acquisition, high

> In the future, data centers (DCs) will no doubt be the convergence points of most services. It will require the DC-centric transport network to be more flexible and elastic, allowing cloud-based services to be adjusted rapidly.

costs, and a long site construction period of five-to-six months. The operator then worked with Huawei on a joint innovation project. By adding side cabinets to existing fixed network cabinets, it solved the problem of site acquisition. The mobile base stations shared the power supply and backhaul fiber resources with fixed networks, shortening the deployment period by two to three months, reducing the overall cost by 30 percent, and greatly accelerating the provisioning time of the operator's mobile services.

Apply automation, intelligence, and cloud-and-network synergy to transport networks

Mobile Edge Computing (MEC) on mobile networks needs to be moved downstream, enterprise services must be moved to the cloud, and BNGs on fixed networks need to be virtualized. In the future, data centers (DCs) will no doubt be the convergence points of most services. The converged transport network will also become a DC-centric network. Service traffic tends to be meshed, and the boundaries of traditional DCN, DCI, and MBH networks will become blurred and converged. This will require the transport network to be more flexible and elastic, allowing cloud-based services to be adjusted rapidly and the cloud and network to be synergized.

Based on the SDN-based on-demand network solution provided by Huawei, China Telecom provides its hospital customers with collaboration between agile private line and e-Cloud. In the daytime, regular bandwidth is used to ensure the transmission of medical data to the cloud. In the evening, the bandwidth can be flexibly expanded to synchronize large amounts of gene sequencing data to the cloud. For hospitals, this ensures service speeds, while reducing costs. Operators can also use idle bandwidth at night to improve bandwidth utilization.

Different services have different requirements and pose various challenges to transport networks. Compared with 3G/4G networks, 5G requires 10 times more bandwidth, millisecond-level latency, and massive numbers of connections. Video services on fixed networks focus on user experience. For services such as HD video, 3D video, VR, and AR, ensuring an optimal interactive experience without artifacts and freeze frames has become a major challenge for transport networks. The B2B private line service focuses on SLA assurance and fast TTM. To implement multi-service bearing, network slicing divides physical networks into different

> To cope with the uncertainties, the architecture of the transport network, which serves as an infrastructure network, must be flexible and feature an agile and intelligent management and control system.

logical networks to provide differentiated network capabilities.

In the 5G era, the converged transport network will be a simplified, intelligent, open, and elastic transport network that centers on distributed DCs, enables automation and intelligence through SDN, and provides slices for different services.

Adopt new protocols as the cornerstone for building converged transport networks

IP will dominate future networks, and traditional architectures based on distributed control will slowly start to feature centralized SDN control. During this process, a series of new protocols, such as Segment Routing, EVPN, Telemetry, and NETCONF/YANG, will become the cornerstone of future converged transport networks.

During the construction of 5G transport networks, leading operators in countries like Japan and South Korea and others in Europe require their networks to support new protocols, and plan to deploy these protocols on their networks. Huawei has actively participated in new protocol standardization, and chairs multiple working groups in the IETF standards organization. It's also an active promoter of and contributor to new protocol standards.

Apply precise planning, platform readiness, and gradual evolution

That future networks will be multi-service cannot be denied. However, some factors regarding service network construction, such as the location of mobile MEC, the pace of bandwidth development, and intelligent O&M requirements, are still uncertain. To cope with the uncertainties, the architecture of the transport network, which serves as an infrastructure network, must be flexible and feature an agile and intelligent management and control system.

Much like a city's sewage network, transport networks need to be planned in advance and deployed phase by phase based on service development. Today, the total length of the sewers in Paris exceeds 2,300 kilometers, far beyond the length of the subway lines in the Paris Métro. This makes it the world's most prestigious sewage system, as well as the only underground drainage system in the world open to visitors. However, it took more than 20 years for Paris to build sewers longer than 600 kilometers. Operators in both developed and developing countries, such as China, Germany, Spain, and the Philippines, have started to plan and design the architecture for future-oriented

> Much like a city's sewage network, transport networks need to be planned in advance and deployed phase by phase based on service development.

converged transport networks according to the actual conditions of their live networks. They have also developed an evolutionary path to the target network, which is a necessary step.

5G networks can't be deployed overnight. The construction period of the transport network is long and has many different requirements. Before the arrival of 5G, we need to conduct research into future service development trends and service traffic. We then need to quantitatively evaluate new mobile 5G spectrum and site scale, DC distribution, the growth rate of home broadband bandwidth, and enterprise private line requirements. And we need to plan the target network architecture in advance and specify the baseline requirements for product software and hardware capabilities.

Based on a clear target network, we can evaluate the gap between the architecture and device capabilities on the live network, and gradually reconstruct and upgrade legacy devices to make them platform ready. During network construction, new features can be introduced and network capacity gradually expanded in phases to achieve smooth evolution to 5G.

The road to ubiquitous connectivity starts with 5G transport networks.

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

By Haiyi Zhang, China Academy of Information and Communications Technology (CAICT)

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

> 5G will bring a revolutionary service experience and new business models, making innovation in 5G transport evolution a priority.

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**

At the 5G Innovative Development Summit held on September 28, 2018, the group released a white

> 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.

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

> Future transport networks must support 4G, 5G, private line, and other types of services deployed in various modes. These impose new SDN-aided intelligent management and control.

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.

Optimizing the transport network for a better user experience

By Don Frey, Principal Analyst & Ian Redpath, Practice Leader

Ian Redpath

Services are in a rapid state of evolution. Mobile networks have quickly evolved from supporting voice and limited amounts of data to supporting massive amounts of video and gaming traffic. The growing shift to video will drive network traffic and necessitate a higher grade of performance to maintain a high-quality user experience. And mobile gaming is a high-value service that attracts customers and aids customer retention, particularly if the user experience is high-quality.

Many operators' networks comprise many layers of technology that have been deployed over a long period of time. And they have to manage all of the challenges within an environment of business model realities and CAPEX constraints, while also considering how the network will evolve to 5G, which promises new applications and business models but also brings many network performance challenges.

Network operators are correct in asking, "How can I improve user experience and network performance right now, without launching into a time- consuming, expensive next-generation business and network plan?"

> The growing shift to video will drive network traffic and necessitate a higher grade of performance to maintain a high-quality user experience.

User experience is ultimately defined by end to end IP network performance

Today's networks are typically a layered, complex mix of technologies and converged bandwidth

4G is inherently IP. The E2E performance of the IP layer is the aggregate of all of the underpinning network layers and options. All the layers of the network impact performance, and the performance of the IP layer ultimately defines the user experience.

The typical operator's network is a mix of technologies, layered (DWDM/IP/Microwave), and features equipment of varying ages from multiple vendors. The goal of E2E visibility is challenging, as the different equipment can report at different time intervals with different levels of precision.

Many operators have constructed converged networks to minimize CAPEX. The trade-off is the transport network becomes more complex. Additionally, unpredictable traffic bursts can negatively impact an under provisioned or tightly provisioned network.

Historic service assurance is not keeping pace

Hour-or minute-level bandwidth utilization does not reflect the real service experience

With LTE and 5G to come, radio access networks are capable of higher speeds, services come with lower latency requirements and users demand higher network availability. The service mix has changed with the rise of web-scale video. And traffic has become less predictable. Earlier generations of service assurance sampling techniques aren't keeping pace with the new, more dynamic environment. Historically, service assurance sampling has been conducted in intervals of minutes to hours. Packet loss ratio over the lengthier intervals can be within acceptable thresholds over the timeframe of the whole interval. The weakness of this approach is very short-term bursty traffic events that may cause short-term packet loss. A small number of packets lost will not impact an email service, but this can cause dropped VoLTE calls or a poor video stream. The net result is a negative user experience that's immediately detected by the user, but may go undetected by the network operator.

> Networks are not static: the number of users and services and the amount of bandwidth per user are growing. Networks that are optimally sized for today's conditions may quickly become undersized for future growth scenarios.

With finer sampling granularity, traffic bursts can be clearly identified. Fine-grained sampling is vital to stay on top of network performance and the user experience in today's environment.

Experience-oriented transport construction and optimization, and an approach to fine tune today's backhaul network

Networking planning to optimize user experience while minimizing CAPEX

Network planning is a balancing act. Network operators can elect to overbuild, or over-provision, to minimize network congestion and maintain a high-quality user experience, but they will need more CAPEX to accomplish their goal. Networks can also be optimized based on today's average network requirements. The near-term appeal of this is lower CAPEX, but the risk is that the network is under-provisioned for bursty

> The new big data analytics approach will need to detect network performance anomalies, and machine learning will be needed to identify network deficiencies and predict future deficiency scenarios.

or unforeseen conditions, which will impact user experience. Networks are not static: the number of users and services and the amount of bandwidth per user are growing. Networks that are optimally sized for today's conditions may quickly become undersized for future growth scenarios.

In today's 4G networks, some network operators have elected to follow the fully provisioned route to minimize congestion bottlenecks. Backhaul networks have been sized to carry the maximum load of the base station. Statistical multiplexing has not been employed to avoid packet loss due to network congestion. An operational consideration factored into the fully provisioned backhaul philosophy is that radio access operations teams do not want to troubleshoot transport backhaul networks. An argument could be made that this approach adds to the near-term CAPEX requirement.

Increase the service assurance sampling frequency

Increasing the service assurance sampling frequency per QoS flow will address the visibility issue for network operators. Next-generation service assurance has the potential to identify a variety of suboptimal network conditions.

While enabling pinpoint precision in identifying network trouble, next-generation service assurance, with advanced telemetry capabilities, will generate vast amounts of data. In the advanced telemetry era, the challenge is to find the underperforming network item in this data. Big data tools are designed to quickly ingest massive quantities of event data and support low-latency queries on that data.

The new big data analytics approach will need to detect network performance anomalies, and machine learning will be needed to identify network deficiencies and predict future deficiency scenarios. Advanced telemetry may mean a vast number of scenarios sound the alarm, so advanced correlation techniques will be required to distill these down to the root cause of the problem. The next-generation service assurance tool will have an advanced dashboard display to rapidly deliver insights on the network.

The future: closed loop automation and integration with SDN control

The longer-term goal of network management is

> The transport network plays a major role in end-to-end (E2E) mobile network performance and the user experience. Network operators need to optimize the transport network in a capital-efficient manner to optimize the user experience.

closed-loop automation, with more powerful analytical tools in place to both identify and predict network problems, and the underpinning capabilities in place to take corrective action. The advanced telemetry tool can supply future orchestration tools, identifying the network scenario and deficiency, and providing the recommended action. The orchestration tool can decide on the best course of action and then request an action. Bandwidth can be flexed up to address congestion issues. Traffic can be rerouted to preserve the service and the user experience.

Conclusions & Recommendations for operators

The transport network plays a major role in end-to-end (E2E) mobile network performance and the user experience. Network operators need to optimize the transport network in a capital-efficient manner to optimize the user experience. Packet loss of less than 10-4 and latency of 50 ms are the recommended performance targets for today's networks. Future ultra-reliable and low-latency 5G services will have even more stringent performance requirements.

The historic service assurance technique of measuring the transport network by utilization in minutes or hours does not provide an accurate view of today's service performance. Network operators need to understand the state of the transport network with fine-grained precision. The standard of precision needs to be improved from minutes or hours to seconds or sub-seconds. With improved network visibility, network operators can consider courses of action for problem remediation.

Transitioning to a new service assurance operational approach is a major endeavor. Network operators with the necessary skill sets can transition to next-generation service assurance tools on their own. Operators can consider partnering with a service assurance specialist to accelerate the transition process to a next-generation service assurance paradigm.

Identifying network trouble spots with precision means many potential remediation actions can be considered. Many actions would require a change in an operational procedure. Some remedies may involve CAPEX. With more precise knowledge of major network congestion points, operators can deploy capital as efficiently as possible for maximum benefit.

How China Mobile Zhejiang became a pacesetter in 5G transport networks

Already a 4G leader in China, China Mobile Zhejiang is demonstrating outstanding performance in the 5G transport field. Together with Huawei, it recently completed the Phase-II pilot construction of its 5G transport network. Supporting up to 120 gNodeBs, it's the largest network of its type in China. It also leads in terms of 5G features, including Segment Routing and FlexE.

By Diao Xingling, Huang Haifeng, Communications World

High network requirements

Compared to 3G and 4G, 5G delivers higher bandwidth, many more connections, and lower latency: it's at least 10 times faster than 4G, its connection density is expected to reach 1 million per square kilometer, and low latency is required by applications like autonomous driving.

Shen Gangwei, Vice GM for the Department of Planning and Technology of China Mobile Zhejiang, believes that these requirements in major service scenarios greatly impact transport networks and access and aggregation equipment rooms, increasing pressure on operators.

5G's higher service requirements

> Networks are not built in one day. Resources must be well-prepared with a clear plan. China Mobile Zhejiang realized the importance of basic resources preparation during the construction of 4G networks.

— Shen Gangwei, Vice GM for the Department of Planning and Technology, China Mobile Zhejiang

> Conducting research and preparing transport resources earlier will mean faster network construction and stronger network bearer capabilities.

From the perspective of wireless and core network evolution, 5G places new requirements on the transport network in terms of bandwidth, latency, synchronization, flexibility, network slicing, and service provisioning.

First, the transport network requires more flexible and agile connections, which necessitates SDN for hierarchical management. Second, the need for rapid service provisioning and deployment requires network slicing to build a full-service, all-scenario 5G transport network. Third, the distribution of 5G service units, centralized units, and distributed units is significantly different from 4G. Therefore, L3 functions will need to be moved downwards on the future transport network. Finally, the bandwidth capabilities of 5G networks will increase continuously. Currently, Packet Transport Network (PTN) devices mainly use GE and 10GE interfaces and can support 100GE interfaces. In the 5G era, the bandwidth will evolve to 10GE, 25GE, 200GE, and 400GE at different network layers. This tremendous bandwidth growth will drive the birth of new technologies.

In the early stage of development, Shen says that, "China Mobile Zhejiang will expand and upgrade its live PTN. In the future, we will introduce new technologies and devices such as Software-defined Packet Transport Network (SPTN)."

The key step

The transport network is the foundation of 5G development. However, networks aren't built in a day and resources must be well-prepared and planned, lessons that China Mobile Zhejiang learned during the successful construction of its 4G networks. According to Shen, "Conducting research and preparing transport resources earlier will mean faster network construction and stronger network bearer capabilities."

According to 5G site construction requirements and technical standards, the impact of 5G on the transport network is mainly felt in the metro network. "We started 5G research and began preparing basic resources in 2016," says Shen. "Our research focuses on physical resources such as access and aggregation equipment rooms, rack space, power environment, auxiliary power supplies, and optical fiber resources on the metro network, as well as the network environment."

The operator started to prepare network resources for access and aggregation equipment rooms in 2017, conducting multiple surveys on live networks and

collecting large amounts of data. And this paid off-a bottleneck in network was identified.

China Mobile Zhejiang used its findings to consolidate and optimize its resources during 2018, including equipment rooms, optical fibers, power, and auxiliary power supplies.

Building a "5G City"

Constructing a network model and doing theoretical research are far from enough to put a network into commercial use. Pilot tests on the live network are also required.

China Mobile Zhejiang has a unique advantage in live-network testing. Hangzhou is among the first batch of cities where China Mobile carried out 5G field trials, covering multiple scenarios such as scale tests, application development and incubation, service experience promotion, and 5G agile R&D.

Its 5G field tests achieved good results and, on the eve of World Telecommunications Day 2018, China Mobile Zhejiang officially launched its 5G City plan, revealing that it will be partnering with Huawei to transform Hangzhou into an innovation hub and pilot city for 5G networks, with continuous coverage available across vertical industries. Plans include an E2E 5G trial network with more than 100 sites by the end of 2018.

The 5G field test was an E2E verification that covered the wireless, transport and core networks. Shen explains that, "The field trial helps us find the shortcomings of our theoretical research. We've since improved our model and completed a new round of planning for transport network construction. We'll work with Huawei and other suppliers to increase the scope of testing and verification, and continue to improve the model in the next stage."

When it comes to planning a 5G transport network, he states that 5G is currently in the phase of testing live networks and researching service applications. In the early stage, 10G to 100G will meet the access

> China Mobile Zhejiang will adjust and upgrade the capacity of the boards and devices on its live networks, and introduce cost-effective new network construction technologies to pave the way for transport networks.

requirements of a small number of gNodeBs under an overall strategy of expanding the live network's capacity. Doing so includes upgrading the aggregation nodes and access rings, starting with the management and control system, and then gradually moving the L3 functions downwards.

In the mid-phase, China Mobile Zhejiang will consider network-wide capacity expansion according to 5G service volumes and network traffic. In hotspot areas and core urban areas, it will deploy 200G or 400G interfaces to meet E2E capacity expansion.

SDN, L3-to-edge deployment, and network simplification will be almost fully completed at this stage.

In the long-term, over 400 Gbps of traffic will be introduced at the core layer to address rapid traffic growth. China Mobile Zhejiang will adjust and upgrade the capacity of the boards and devices on its live networks, and introduce cost-effective new network construction technologies to pave the way for transport networks.

A flourishing 5G ecosystem

5G networks carry a large number of service applications, the development of which needs to be in sync with network construction.

At present, 5G standards have basically been determined, some technologies have been verified, and 5G service applications are proliferating, especially IoT applications. However, 5G field trials suggest that more research and testing is needed on 5G terminals, equipment manufacturing, and live-network capacity expansion. Moreover, continuous network improvements are needed to meet the requirements of high bandwidth, massive connections, and low latency.

As well as its network trials, China Mobile Zhejiang has promoted the development of the 5G industry and applications, especially services related to manufacturing, lifestyle, society, culture, and IoT applications.

In 2016, China Mobile and Zhejiang Provincial Government jointly built a 5G Joint Innovation Center and a center for 5G technologies and service applications that supports infrastructure construction and 5G technical standards. It also

> China Mobile Zhejiang's next step will be to expand its 5G trial network to cover multiple areas. In addition, it will promote research into applications such as industrial Internet, Internet of Vehicles (IoV), Smart City, and VR/AR.

launched the trial commercial use of 5G products and services.

In 2017, the operator and local government worked with various enterprises to set up the 5G New Technology Research Joint Lab to promote a complete 5G industry chain, covering chips, algorithms, network devices, and terminals, aiming to position the lab as a benchmark for 5G technology research in China. On the eve of World Telecommunications Day 2018, China Mobile Zhejiang and several dozen organizations, including operators, device vendors such as Huawei, research institutes, and major companies in various industries, jointly established the 5G Industry Alliance of Zhejiang Province.

IoT and 5G

China Mobile Zhejiang has already deployed NB-IoT applications, such as remote monitoring and meter reading, with its NB-IoT coverage powering some of the largest-scale projects in the country. In fact, the operator's IoT connections have already exceeded the number of its mobile and fixed subscribers.

China Mobile Zhejiang's work in the 5G industry will also promote the development of 5G transport networks. "We will closely cooperate with the Ministry of Industry and Information Technology (MIIT) and China Mobile Group in terms of the scale and progress of 5G transport network construction," says Shen.

China Mobile Zhejiang is ahead of China Mobile as a whole in the construction and preparation of network infrastructure resources, especially those for transport networks. And Shen hopes that Hangzhou will become a national 5G leader.

China Mobile Zhejiang's next step will be to expand its 5G trial network to cover multiple areas, such as West Lake, the Asian Games Stadium, IoT Town, and Zhejiang University. In addition, it will promote research into applications such as industrial Internet, Internet of Vehicles (IoV), Smart City, and VR/AR, as well as demonstrations of these technologies.

Thanks to its fearless persistence and planning in the 5G field, the operator has already made a name for itself as a 5G leader in China, and plans to keep it that way.

New business models for multi-service 5G transport networks

GSMA forecasts that by 2025, the number of global 5G connections will reach 1.1 billion, with one-third of the world's population connected to 5G networks. As the 5G industry matures, 5G will enable the connectivity and digitalization of everything. As a result, the operator market will extend from individuals and homes to industries, an area that will integrate further with ICT.

By Li Guang

> When transitioning to a multi-layered and converged business model, operators need to match various services in accordance with connections, platforms, integration, and operations modes.

Deeper connections and a new business model

The future operator network is oriented towards 5G and supports new services such as enhanced mobile broadband (eMBB), ultra-reliable and low-latency communications (uRLLC), and massive machine-type communications (mMTC). This meets the requirements of different services for bandwidth, latency, and intelligence, allowing 5G networks to develop more and connect everyone to everything.

The B2C domain is set to evolve from mostly video towards making our personal lives digital. While the B2C domain allows for quick monetization, it also poses the biggest challenge for operators, which means that the business model may need to change, especially in terms of brand, service model, and charging metrics.

B2B industry applications will become key territory for operators' mid- and long-term success, as business restructuring and innovation in vertical industries takes center stage.

To support a wide range of new 5G services, service diversification is required on a single network. Differentiation and balance are vital, especially in terms of mobility, number of connections, E2E latency, reliability, mobile data volume, service deployment time, and energy efficiency. As the pipe and information highway for 5G networks, transport networks need to be intelligent to meet the special requirements of 5G services. The challenges of high bandwidth, low latency, complex connections, time synchronization, fragmentation, and intelligent O&M faced by 5G transport networks require smooth evolution and quick adaptation to enable intelligence and cloudification.

In general, as 5G services and value chains evolve, traditional operators are gradually building a converged and multi-layered business model based on connections. The concept of multi-layered monetization takes shape in terms of connectivity (connections, mobile edge computing, and slicing), platforms (IaaS and data platforms such as IoV and video surveillance), integration (one-stop industry

> When it comes to the more flexible evolution of transport networks, functions can now be added and expanded through software DevOps instead of purely adding network hardware.

integration), and operations (E2E operations services such as unmanned aerial vehicles and VR). Given the relationship between solution and device providers and operators, the network construction of 5G transport networks will change as operators' business concepts change.

Multi-service 5G scenarios

When it comes to the more flexible evolution of transport networks, functions can now be added and expanded through software DevOps instead of purely adding network hardware. In traffic-driven scenarios, the capacities of transport networks used to be expanded based on pipes only. To adapt to operators' future multi-layered and converged business models, the evolution of transport networks needs to be more flexible. At the same time, software-centric operations are necessary to enable DevOps, connect seamlessly with operators to respond to new requirements, adapt to new scenarios, and enable joint innovation.

So that transport networks can handle service-oriented procurement for new 5G service scenarios, industry applications are evolving. Operators need to perform trial and error tests and joint innovation to find the most cost-efficient methods and generate quick profits. To be able to respond quickly to uncertain requirements, procurement has to shift from one-off transactions to service-based purchases. To adapt to this change, transport networks, which serve as smart pipes, need to optimize and innovate procurement though traffic models, scenario classification, and value sharing. Traditional one-stop purchases may end up being replaced by installments and dispersed purchases, depending on models and service capabilities, including traffic models, scenarios, value packages, Subscription and Support (SnS), and Right to Use (RTU).

When transitioning to a multi-layered and converged business model, operators need to match various services in accordance with connections, platforms, integration, and operations. Therefore, transaction and charging modes will also change considerably. Operators need to provide end users with periodic leases or subscription services to support the operations-oriented business model. And that means the way transport networks suppliers and operators collaborate will change accordingly. In a B2B2C scenario, periodic leases and subscription services

> To be able to respond quickly to uncertain requirements, procurement has to shift from one-off transactions to service-based purchases.

may be implemented synchronously. This requires operators and their partners to build a converged and long-term strategic partnership, and requires operators to recognize the value of their partners' long-term services.

A new business model is needed

The business model for multi-service bearing needs to adapt slowly to be compatible with 5G application scenarios and the extension of operators' value chains. Essentially, a new multi-layered business model needs to be built.

New business model for multi-service 5G transport networks

Business models emphasize that customer value, resource capability, and profit models must match. Unlike traditional transport networks, multi-service 5G transport networks are changing profoundly in terms of customer selection, value proposition, internal and external resources, cost, and profitability. Underpinning the business model, multi-service 5G transport networks will evolve in terms of transaction models, delivery content, and delivery methods.

Evolution of value proposition, profit model, and transaction model

For networks to be cloud-based, intelligent, and elastic, multi-service transport networks have to make network features and scenario classifications both software-based and perceivable by decoupling software and hardware. To make users aware of the value of network slicing, multi-service bearing, low latency, and intelligence, transport networks may have to sell resources and capabilities. For example, with the Internet of Vehicles, the value proposition of intelligence, low latency, and high reliability is packaged into a network slice, and an independent profit structure is designed to maximize that value proposition.

Transaction modes are also becoming more diverse. RTU, permanent license and SnS, subscriptions, and SaaS can be implemented between device providers and operators to share benefits, costs, and risks. Furthermore, new B2B2C models can be developed to allow everyone to benefit from opportunities in the 5G industry.

RTU is an authorization mode used to sell hardware capabilities in installments, such as capacities,

> To provide various services, a core brain engine driven by business intent is required. This engine, together with business intent and network infrastructure, forms a closed-loop system.

ports, and frequencies. Operators can purchase ports and capacities on demand to reduce initial investment and achieve the goal of environmental protection.

License/SnS and subscription modes convert operators' OPEX into smooth annual expenses. They can promptly receive software upgrades and upgrade services provided by vendors, reducing network risks, improving service quality, and resolving routine problems with network O&M.

Extending delivery modes and content to more specialized fields

5G features require that transport networks be in place before 5G can be deployed commercially. 5G also requires the presence of multi-service bearing, scenario-specific applications, elasticity, and separate purchasing. On transport networks, operators will be able to carry multiple services, including wireless services, B2B private lines, and fixed network services. Scenario-specific slicing support can also be provided. The bearer channel must be elastic enough to implement on-demand resource allocation for performance, latency, and reliability. Delivery content can also be quickly corrected based on annual fees, and new features and requirements can be imported. Service modes and delivery content will extend to more converged and specialized service fields to integrate with operators' platforms, data, and industry integration, providing more accurate management, control, and data analysis services.

To provide specialized services, transport networks need to be simple and more intelligent. This requires a core brain engine driven by business intent. The engine can match changes in the delivery content and mode based on transport networks. The engine, together with business intent and network infrastructure, forms a closed-loop system, or in other words, an Intent-Driven Network. The engine must be equipped with management, control, and analysis capabilities. Specifically, the engine must be programmable, model-driven, and capable of implementation control, open APIs, cloud-based architecture, data analysis, and AI.

The continuous evolution of various elements of the new business model can guide investment by operators. Moreover, through joint service innovation with operators, transport networks providers can achieve rapid service deployment in the 5G market.

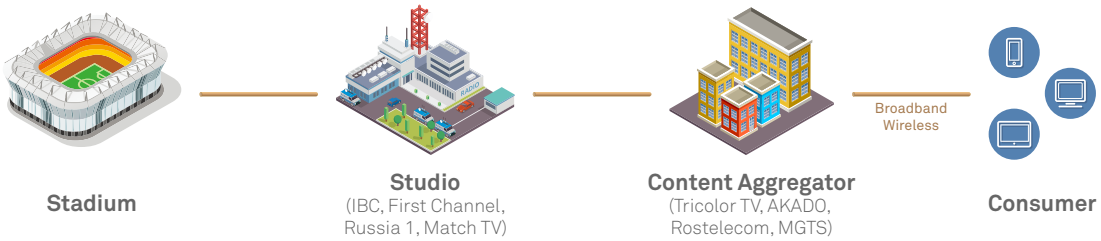
Private line transformation for media and broadcast services creates a new market for operators

By Wang Weibin

High-definition (HD) or ultra-high-definition (UHD) video signals are essential to meet increasing consumer demands for content and experience. Higher rates are needed to bear HD/UHD signals, which in turn drives the upgrade of private lines for media and broadcast services. Forming the network infrastructure of the video industry, private lines for media and broadcast services have many potential high-value customers that represent an untapped revenue source for operators.

From camera to screen

Not only did the 2018 World Cup keep fans glued to



Signal distribution process in Russia

> The distribution of video and audio signals from camera to screen imposes high requirements on the bandwidth, reliability, latency, and O&M automation of the transport network. Professional service providers are required to provide private line services.

their screens, the event also provides a good way for us to show how audio and video signals arrive on the viewer's screen from the camera lens.

In each venue (12 in total), 37 UHD 4K HDR cameras (15 Gbps native signals) collected signals and communicated with the International Broadcast Center (IBC) in Moscow. This enabled public TV signals to be produced and media-oriented materials to be distributed. Russian TV stations with broadcasting rights, such as First Channel, Russia 1, and Match TV, obtained the public signals and materials for post-production, for example, editing, dubbing, and inserting ads.

This is first-stage distribution, or the contribution, of media and broadcast service signals where original video signals, live broadcasts and program photography are sent from a signal collection venue such as a stadium or TV base to the production studio. Alternatively, original video signals are distributed between multiple production studios for collaborative production. The main players are TV stations and live broadcast companies, such as the BBC and IMG studios, a production company for the Premier League.

TV stations then distributed the completed World Cup programs to the video program aggregator and distributors, including Tricolor TV, AKADO, Rostelecom, and MGTS.

This distribution of the video and audio signals is called primary distribution. Signals are distributed from production studios, for example, TV stations or film and TV companies, to content aggregation and distribution providers such as cable TV, IPTV, OTT, and satellite providers. The main players are TV stations such as the BBC, CNN, CCTV, and Sky.

After obtaining program content, the video distributors transcode and adapt the video and audio, and then distribute the content to subscribers.

This distribution of video and audio signals is called secondary distribution. Signals are distributed from content aggregation and distribution providers to subscribers.

For secondary distribution, the main players are multi-service operators (MSOs), telecom operators, satellite TV service providers, and OTT providers. They purchase, aggregate, and deliver content to subscribers, and generally operate self-built and self-used networks.

> From SD to HD to UHD (4K and 8K), people expect more from resolution, frame frequency, color depth, and channel improvements. Compression isn't used because it can affect post-production and compromise the original content.

To achieve contribution and primary distribution, private lines and networks are built for content producers, including broadcast and TV stations. Broadcast and TV stations themselves focus on content production and lease and purchase private line and network services from third-party operators, which undertake network construction and maintenance tasks.

The contribution and primary distribution of media and broadcast service signals are oriented towards video producers and distributors. Therefore, these are the typical application scenarios where operators provide media and broadcast services with private lines or networks.

The distribution of video and audio signals from camera to screen imposes high requirements on the bandwidth, reliability, latency, and O&M automation of the transport network. Professional service providers are required to provide private line services.

Increased replacement of private lines

Currently, the data collected by cameras is generally outputted through the serial digital interface (SDI). The original video content is transparently transmitted to production studios without being compressed. Compression isn't used because it can affect post-production and compromise the original content. Uncompressed original video content helps simplify and standardize the IT systems of production studios. However, uncompressed content results in a tenfold or more increase in the volume of transmitted data, creating huge bandwidths requirement on the entire transport network.

In addition, new video technologies are changing the way people consume media and broadcast services. From SD to HD to UHD (4K and 8K) and 360-degree panoramic VR, people expect more from resolution, frame frequency, color depth, and channel improvements.

As a leading organization in the media and broadcast industry, the Society of Motion Picture and Television Engineers (SMPTE) has defined video and audio signal standards. From the traditional SD-SDI to today's mainstream HD/UHD, the video signal rate has increased from 10- to 40-fold.

SD-SDI signals have given way to 1.5 Gbps HD-SDI (720p and 1080i) and 3 Gbps 3G-SDI (1080p) signals. 4K/UHD cameras (running at a rate of 12 Gbps or higher) are becoming the go-to choice for boosting

Standard	Name	Bitrate	Example Video Format
SMPTE 259M	SD-SDI	270 Mbit/s	480i, 576i
SMPTE 344M	ED-SDI	540 Mbit/s	480p, 576p
SMPTE 292M	HD-SDI	1.485 Gbps	720p, 1080i
SMPTE 372M	Dual Link HD-SDI	2.970 Gbps	1080p60
SMPTE 424M	3G-SDI	2.970 Gbps	1080p60
SMPTE ST-2081	6G-SDI	6 Gbps	1080p120, 2160p30
SMPTE ST-2082	12G-SDI	12 Gbps	2160p60
SMPTE ST-2083	24G-SDI	24 Gbps	2160p120, 4320p30

user experience.

Broadcast and TV companies are also increasing UHD programs for popular sports events and live broadcasts by using more cameras and generating more content. As a result, the volume of audio, video, and data being transmitted from venues is increasing. To transmit the Premier League, for example, BT provides private lines from 20 venues to the IMG Studio for remote production and to transmit live, uncompressed HD signals. During each game, 20 to 34 cameras are provided for the multi-angle capture of uncompressed HD video signals.

In 2017, the number of signal channels in a match venue was 24, 20 channels of HD 1.5 Gbps signals and 4 channels of 150 Mbit/s signals, up from the initial 10 to 12 channels. Total bandwidth was 30 Gbps. Thus, separate routing was needed to improve reliability, which requires 60 Gbps of bandwidth for each venue.

Broadcast copyright purchasers now expect better event signals. For example, Sky requires 4K signals and VR live broadcasts for Premier League, and thus a higher network rate is required for capacity expansion.

The requirements for better SDI signal rate and user experience both necessitate an increase in the speed and capacity of WAN interconnection interfaces and also underline the need for higher SLAs for private lines. To meet these requirements, traditional private lines must be upgraded.

Larger network bandwidth: Traditional 10G WDM networks cannot support HD/3G-SDI or future-oriented UHD 12G/24G-SDI evolution, because 4K/8K and higher bandwidth requires a single wavelength at 100G/200G.

Higher reliability: The 99.9% reliability and robustness of DWDM ring networks lack sufficient protection capabilities. At least 99.99% is required to ensure less than 52 minutes of downtime per year.

Lower service latency: Traditional network architecture is complex, with a variety of devices. Both signal conversion and compression negatively

> Uncompressed content results in a tenfold or more increase in the volume of transmitted data, creating huge bandwidths requirement on the entire transport network.

affect E2E service latency and stability. As a result, signal distortion and damage occur, especially in live broadcasts. To ensure lossless transmission of HD video signals and cut costs, network architecture must be simplified and a transport solution that guarantees low latency and zero packet loss provided. A major player in the industry in Germany, for example, requires less than 5 ms latency to improve user experience.

Automated service provisioning and visualized O&M: Services used to be provisioned by manual connections, resulting in low efficiency, lengthy service provisioning, network invisibility, and complex O&M. SDN provides agile and automated service provisioning and flexible adjustment capabilities, which speeds up service provisioning. SDN also visualizes network resources and service performance and simplifies O&M.

Enhanced security: To ensure copyright protection and enhance content security, service-independent physical-layer encryption is provided.

Traffic growth boosts development potential

Potential high-value customers are widely distributed because every country has requirements for upgrading its private line and networks for media and broadcast service transmission. An extremely reliable transport network is required to collect

User	Private Line/ Network Service Provider	Contract Duration	Contract Period
BBC Aurora	BT M&B	7 + 3 years	From 2017 to 2023
BBC	Vodafone	10 years	The contract was signed in 2004 and expired in April 2017.
ITV	BT M&B	5 years	From 2013 to 2018
NPO (Netherlands)	KPN	5 to 7 years	From 2014 to 2019/2021

> Uncompressed content results in a tenfold or more increase in the volume of transmitted data, creating huge bandwidths requirement on the entire transport network.

content at the front end, transmit it back to the production studio, enable collaborative video production among multiple branches, and ensure back-end video content distribution and broadcasting. The market potential is huge.

State-owned/commercial TV stations, and broadcast and TV companies

Large-scale events, such as the Olympic Games, World Cup, European Cup, Asian Games, Commonwealth Games, and Europe's big five football leagues, are increasing the deployment of Fiber to Venue and remote production.

Professional video and image editing and production companies

Of the top TV stations that provide media and broadcast services, more than 20 national TV stations are located in Western Europe. Each TV station has a private network built to transmit outside broadcasting signals back to production studios for remote production.

Alternatively, the private network is used for WAN interconnection between multi-facility production studios, interconnection between video and audio data centers, and data archiving. Here are some examples:

In 2016, the BBC invested £100 million and contracted BT to build private lines.

Private lines are usually leased for a 5-to-10 year contract period and therefore offer a stable, long-term source of income.

Operators can specify a minimum service life; for example, BT requires a minimum of five years in its contracts. Therefore, private lines and networks offer a stable, long-term source of income for service providers.

Operators are the main builders

Both telecom operators and MSOs are major players in the private line field.

The top telcos have provided private line services for TV stations and large-scale events; for example, BT provides private lines and networks for the BBC, ITV, and Premier League, and KPN provides private lines and networks for the NPO.

Unlike telcos that provide only private lines and networks, some MSOs can produce content. In

> In addition to providing private line services for their own TV stations, MSOs are expanding the private line market to provide private line services for other content producers.

addition to providing private line services for their own TV stations, MSOs are expanding the private line market to provide private line services for other content producers.

Telcos have advantages over other media and broadcast service providers in transmission resources, network and optical fiber coverage and acquisition, bandwidth cost, and network management experience. Therefore, they're the main builders of media and broadcast private lines. As existing contracts are expiring and new bids are issued to upgrade legacy private lines to expand private line services, operators can enhance their competitiveness in solution differentiation and overall costs, develop services for customers, and provide high-quality private line and network services.

Huawei is working with German operators to build agile and flexible private lines and networks based on the OTN solution for German TV stations. The private lines feature ultra-high bandwidth, low latency, high reliability, and simple architecture.

The countdown to commercialized operator-provided Cloud VR has begun

By Zhang Jinshui, China Mobile Fujian

In 2014, Facebook's US$2 billion acquisition of the virtual reality hardware company Oculus brought about explosive growth in the VR industry. The market research institute IDC predict that the sales volume of VR/AR devices will increase from 8 million units in 2017 to 12.4 million units in 2018, reaching 68.9 million in 2022, an 800 percent rise over 2017.

Despite the positive outlook, the popularity of VR is still facing challenges. For example:

- Host VR devices that deliver a good experience are prohibitively expensive for the average person.
- Head-mounted displays (HMDs) aren't comfortable due to weight.
- Cord connections degrade experience.
- The VR ecosystem is disorganized, which complicates content acquisition.

Cloud VR can address these problems by transferring video storage and game rendering to the cloud. Telecom operators have E2E communication networks, mature video service platforms, and massive user bases. Therefore, they have unique advantages in providing Cloud VR services.

China Mobile Fujian: A Cloud VR pioneer

As the leading full-service operator in Fujian province, China Mobile Fujian (China Mobile Fujian) focuses on customer experience to deploy high-

> Telecom operators have E2E communication networks, mature video service platforms, and massive user bases. Therefore, they have unique advantages in providing Cloud VR services.

quality communications networks, providing, for example, ultra-HD 4K video services for 4 million broadband TV users in the province. To further explore network potential, maximize the commercial value of gigabit home broadband, and extend its leadership in the network, service, and quality domains, China Mobile Fujian joined Huawei and VR industry partners in launching the world's first Cloud VR service-AND Cloud VR on July 18, 2018. This launch marked the first step of China Mobile Fujian's smart home video service into the VR era.

Cloud VR solves several problems in the VR industry, but also places higher demands on operator networks. At least 200 Mbit/s bandwidth and less than 20 ms E2E network latency (fair-experience phase) are needed. Small problems on networks are easily amplified, affecting end user experience. Therefore, Cloud VR is a true test of network quality. Based on high-quality optical broadband networks and 4K video operation experience, China Mobile Fujian successfully launched the world's first Cloud VR service, bringing high-quality VR products to the home.

Major features

Cloud computing reduces costs

At present, host VR devices that deliver the best experience in the industry need to be accompanied by high-performance PCs that cost around US$2,000. In contrast, Cloud VR uses the computing capabilities of cloud platforms as a substitute for PCs. Users only need to purchase an all-in-one VR HMD for about US$300 to connect to broadband through their home Wi-Fi network and enjoy high-quality VR content. The overall cost is reduced by 70 percent to 80 percent, but the experience is just as good as on a high-end PC.

Wireless transmission is free from cable connections

The cords connecting host VR HMDs and PCs greatly interfere with user movement. Cloud VR uses 5 GHz Wi-Fi to achieve the high-speed data transmission of HMD data, eliminating the need for wires and allowing users to enjoy VR services more freely.

An aggregation platform aggregates massive content

In the past, VR content was bound to hardware platforms, and transferring content between platforms wasn't possible. After VR cloudification, China Mobile Fujian built a unified content aggregation platform and implemented software

> In the world's first operator-provided Cloud VR service, China Mobile Fujian has streamlined E2E service processes, and set up a complete Cloud VR technology and service system.

and hardware decoupling with HMDs, making the selection of VR content as simple as selecting a TV show.

Cloud VR enables VR content display on TV screens

Through collaboration between the screen-sharing modules of devices, clouds, and STBs, Cloud VR implements HMD content display on home TV screens. Users can share content in the VR world with family members at any time, meaning that VR has the potential to become the new home entertainment center, replacing TV.

E2E solution verification and optimization enable successful implementation of Cloud VR

In the world's first operator-provided Cloud VR service, China Mobile Fujian has achieved multiple technological innovations and breakthroughs in platforms, networks, terminals, content, and the last-mile connection to intelligent home networks. It has streamlined E2E service processes, and set up a complete Cloud VR technology and service system.

The collaboration of platforms, content, and terminals enables the quick rollout of a high-quality service system

China Mobile Fujian uses the content distribution system and CDN resources on the existing video platform to implement fast deployment of the solution. Only some dedicated systems are developed and adapted, such as the VR video platform, VR cloud rendering platform, and VR screen mirroring system. This saves costs and accelerates service rollout. At the same time, Huawei's VR OpenLab assisted China Mobile Fujian in finding industry-leading partners, acquiring a variety of content resources and VR terminal products, and achieving high-quality service operations.

Well-designed target networks ensure a good user experience

Cloud VR services and video services are similar on the bearer network side. Therefore, Cloud VR services in the fair-experience phase can be quickly deployed by using existing 4K video networks to reduce network construction costs and protect initial investment. In the future, the networks can be further optimized if required. For Cloud VR to be used in home networks, all-in-one VR HMDs must be connected to 5 GHz Wi-

> Huawei's VR OpenLab assisted China Mobile Fujian in finding industry-leading partners, acquiring a variety of content resources and VR terminal products, and achieving high-quality service operations.

Fi to ensure flexible user operations under cordless connections.

The architecture of the integrated bearer network is simplified to ensure the Cloud VR service experience

Cloud VR provides video and game services based on cloud computing. To guarantee high-quality user experience for these services, HD video streams and a fast response are required, which depend on ultra-broadband and simplified networks with high bandwidth and low latency.

In recent years, China Mobile Fujian has constructed a number of high-quality communications networks. Based on the network construction concept of all-optical access, flatness, and low convergence, China Mobile Fujian has built a smooth and stable 4K video bearer network, and therefore quickly provisioned Cloud VR services for some users. However, according to multiple surveys and implementation results, some OLTs on the network still use switch aggregation networking, which features a high convergence ratio and complex homing relationships, and also presents difficulties in carrying Cloud VR services. Some BRASs and OLTs, and also CRs and BRASs, are connected through GE and 10GE links, which cannot address traffic growth. Therefore, further architecture simplification and link expansion are necessary in future service expansion.

Home Wi-Fi network quality needs to be improved for breakthroughs in cordless VR experience

According to live network surveys and lab tests, Cloud VR services are facing many problems and challenges on home networks. For example, 5 GHz Wi-Fi is required because 2.4 GHz Wi-Fi cannot carry Cloud VR services due to narrow frequency bandwidth. Severe adjacent-channel and co-channel interference significantly deteriorates service experience, and therefore signal conflicts must be avoided. Additionally, 5 GHz Wi-Fi devices with uneven quality make results uncertain.

To address these challenges, China Mobile Fujian chose the Huawei SmartWi-Fi solution to achieve the last 10-meter connection. Based on the all-optical access FTTH network, the solution further improves Wi-Fi performance experience for home network terminals and achieves fiber to the home and 300 Mbit/s to the room. Moreover, a smart home networking service is provided to serve the following functions:

· Detecting interference and planning channels in

> It is foreseeable that Cloud VR will become an important application that can be monetized through gigabit broadband services, with a bandwidth of 200 Mbit/s or higher.

advance.

· Offering a strong independent Wi-Fi working frequency band for Cloud VR services.

· Solving the problems caused by coexistence of Cloud VR, Internet access, and IPTV services.

Increasing home broadband revenue

As new territory for both China Mobile Fujian and the entire telecom industry, Cloud VR has no mature business models yet. However, according to an analysis of Cloud VR, at least four types of sales revenue are possible: content revenue, broadband sales revenue, home intelligent networking service revenue, and VR HMD revenue.

They can also be bundled to carry out preferential marketing and quickly increase user numbers. Currently, the Cloud VR service of China Mobile Fujian is only used by about 100 users. China Mobile Fujian planned to develop 1,000 users this year, and to increase the number to 10,000 in 2019. User feedback shows they're satisfied with such a good VR product at a US$300 price tag. Next, China Mobile Fujian plans to introduce high-quality video and game content to further boost user satisfaction.

It is foreseeable that Cloud VR will become an important application that can be monetized through gigabit broadband services, with a bandwidth of 200 Mbit/s or higher, for customer groups with all-optical access.

In general, Cloud VR brings enjoyment, diverse content, and a wide variety of application scenarios to households.

Accessing the enterprise market

Cloud VR also has much potential for enterprises.

Hotels: Competition in the hotel industry is fierce and a VR product experience could be used to show differentiated advantages. However, specialized personnel would be needed to construct and maintain VR systems for hotels, increasing management difficulties and operation costs.

Cloud VR services provided by operators can be used to implement fast deployment, so customers can enjoy high-quality VR content quickly, improving both hotel service quality and customer accommodation experience.

Education: While VR is popular in education scenarios,

> In general, Cloud VR brings enjoyment, diversified content, and a wide variety of application scenarios to households, and is also applicable in many industry markets.

localized deployment is complex, making upgrades and maintenance difficult. By introducing systematic VR education content and leveraging their own broadband advantages, operators can provide simpler and more efficient solutions for schools.

With clear requirements and sufficient funds, these types of industry applications can be easily monetized and provides a focus area China Mobile Fujian.

As the world's first operator to provision Cloud VR services, China Mobile Fujian has made an active attempt to innovate services in the telecom industry. In 2020, the industry will witness the large-scale deployment of 5G. China Mobile Fujian expects to attract more than 50,000 Cloud VR users on 5G networks and provide a mature and stable cloud platform architecture that can be shared with 5G VR services. These lay a solid foundation for the fast rollout of 5G VR services.

Looking ahead, China Mobile Fujian plans to continue working with Huawei to further explore Cloud VR service operations and translate project success into business success.

5G field trials show the power of applications

China Telecom Shenzhen is running one of the first six 5G field trials for China Telecom. In partnership with Huawei, the operator has invested in 5G innovation and begun researching how to commercialize 5G technology.

By Di Xiaokang, China Telecom Shenzhen

> To achieve its goal of connecting 50 5G sites by the end of 2018 while constructing its transport network, China Telecom Shenzhen upgraded its existing IP RAN to deploy and verify 5G technologies, enabling the co-existence of both 4G and 5G.

5G applications based on the 5G trial network

In the Shenzhen Software Industry Base, China Telecom Shenzhen completed the deployment of China Telecom's first 5G pilot site in October 2017 and began the verification of 5G networking capabilities and solutions.

Based on the 5G trial network, China Telecom Shenzhen is exploring 5G application models. During the 5G Unmanned Aerial Vehicle (UAV) flight test and inspection demonstration, remote control personnel experienced VR capabilities and remote HD video transmission over a low-latency 5G network. Both the maiden test flight and inspection were completed successfully, demonstrating the ability of 5G to support UAV applications. This means that aerial photography, unattended inspection, logistics transportation, security identification, and other industrial applications will be driven by the rapid development of 5G in the telecom sector, creating a strong foundation for China Telecom to explore new vertical industries.

In tests on Gbps-level experience buses, 5G provided an average speed of more than 1 Gbps and a peak rate of 3 Gbps, allowing passengers to experience mobile 4K IPTV, 16-channel HD video streams, and VR applications while traveling. This paves the way for China Telecom's plans of 5G and IPTV convergence.

To achieve its goal of connecting 50 5G sites by the end of 2018 while constructing its transport network, China Telecom Shenzhen upgraded its existing IP RAN to deploy and verify 5G technologies, enabling the co-existence of both 4G and 5G. In addition, the operator gained valuable engineering experience and developed scenario-based solutions for subsequent 5G construction.

> The co-deployment of eNodeB and gNodeB is the optimal choice for transport networks, and China Telecom Shenzhen verified different co-existence solutions.

Building application-oriented 5G transport networks

Addressing 5G challenges for the smooth evolution of live networks

While bringing a wide variety of services, 5G also brings challenges in terms of bandwidth, latency, connections, and the slicing of transport networks. GNodeBs, however, deliver five to ten times more bandwidth than eNodeBs. 5G services such as the Internet of Vehicles (IoV) require the latency to be one-tenth of what they are with 4G. In terms of connections, the cloudification of wireless and core networks brings full-mesh connections, requiring flexible scheduling on the transport network. In addition, 5G's differentiated services require network slicing, with a focus on isolation and the automated management of network slices on transport networks. To cope with these challenges, China Telecom Shenzhen assessed the existing IP RAN, opting to upgrade and expand core and aggregation devices and replace specific access devices for 5G transport. To quickly deploy 5G services and fully reuse the existing network, China Telecom Shenzhen implemented the smooth evolution solution for the transport network in pilot areas.

Network upgrade for co-existence of 4G and 5G

The co-deployment of eNodeB and gNodeB is the optimal choice for transport networks, and China Telecom Shenzhen verified different co-existence solutions. Access ring devices can be upgraded and expanded to satisfy the requirements of 50GE ring networking and allow 4G and 5G services to share the same access ring. When access devices need to be replaced, China Telecom Shenzhen can establish a new 5G access ring, which can share the core and aggregation layer to achieve unified service bearing.

E2E large capacity to meet HD video transmission requirements

As China Telecom continues to explore 5G services, the convergence of 5G and IPTV has become its focus. To meet the requirements

of 4K IPTV video transmission using 5G, the transport network must have large bandwidth transmission capabilities. China Telecom Shenzhen upgraded the access layer from an eNodeB GE ring to a 50GE ring, and upgraded the core and aggregation layer from a 10GE network to a 100GE network, allowing high-bandwidth connections between base stations and the core network.

FlexE deployed for vertical industries to deliver NSaaS

In addition to gaining experience in 5G network construction and verifying network technologies, China Telecom Shenzhen hopes to create a 5G demo network for China Telecom Guangdong and even China Telecom Group. It's also aiming to become a base for 5G service incubation and innovation. China Telecom Shenzhen has cooperated with multiple governments and enterprises to launch enterprise-based 5G services. Enterprise services and mobile broadband services have different network requirements. Therefore, in the pilot process, China Telecom Shenzhen proposed network slicing as a Service (NSaaS) to provide customized new services for customers in vertical industries. In the transport network field, FlexE (a hard slicing technology) is deployed to provide independent bandwidth resources for each enterprise application, ensuring the service quality of each and improving user experience.

Cloud-network synergy provides connections for various cloud services

Combining 5G with existing cloud services is a key direction for China Telecom Shenzhen and Huawei to explore 5G applications. The convergence of the existing telecom cloud services and 5G networks that provide high bandwidth, high reliability, and low latency will improve the competitiveness of telecom cloud services and expand the service scope. China Telecom Shenzhen aims to deploy an intelligent O&M platform on the 5G transport network to manage and control the path, bandwidth, and latency of cloud services, and to collaborate with the cloud management platform that delivers cloud services. In the smart policing demonstration of China

> The pilot network of China Telecom Shenzhen was already equipped with 5G capabilities. They also stated that it was essential to work with more industry chain partners to jointly innovate and explore more industry applications.

Telecom Shenzhen's 5G experience buses showcase, the 5G UAV uploads HD images to the police cloud in real time. The cloud superimposes the target information, action route, action area, and other information using AR technology, and displays the synchronized information on the shared command center screen for the 5G buses. This requires orchestration between the transport network and cloud so that high-bandwidth and low-latency connections are provided between the UAV and cloud.

Partnerships build intelligent 5G networks

After visiting the 5G showcases in Shenzhen, China Telecom executives said that the pilot network of China Telecom Shenzhen was already equipped with 5G capabilities. They also stated that it was essential to work with more industry chain partners to jointly innovate and explore more industry applications.

China Telecom cooperates with Huawei to explore the value of the 5G industry. Both parties leverage their advantages to develop the 5G service innovation base, build an industry ecosystem alliance, and research the usage scenarios and business models for 5G services. Huawei Wireless X Labs in Shenzhen simulates 5G technologies and usage scenarios, and works with upstream and downstream industry partners to jointly develop industry standards and plans. China Telecom leverages the resources of 5G trial networks and existing industry customers to develop new 5G applications, driving the development of the entire 5G industry and improving China Telecom's influence in the 5G field.

The world is changing from 4G to 5G, from people-to-people connections to all-connectivity, and from revenue growth driven by demographic dividends to revenue growth driven based on user experience. China Telecom Shenzhen will continue to play a leading role in creating a first-class innovation ecosystem and push forward 5G technological innovation. Based on its pilot projects, China Telecom Shenzhen will collaborate with upstream and downstream industry partners to promote the construction of the 5G ecosystem and construct robust networks for a digital China.

China Unicom

Beijing selects 4G IP RAN evolution to build its 5G transport network

China Unicom Beijing believes that the readiness of the transport network is critical in bringing 5G to market quickly. Therefore, infrastructure resources need to be reserved, and 5G-oriented planning and reconstruction must be completed for transport networks before the reconstruction of wireless and core networks.

By Peng Yang, China Unicom Beijing

> Before approaching 5G construction, China Unicom Beijing evaluated the infrastructure resource requirements of different construction methods on wireless, transport, and core networks.

5G, the next-generation standard in mobile communications, will not only boost user experience, but also enable the large-scale networking of billions of IoT devices. It will allow everything to be connected and facilitate the deep integration of many important industries, such as manufacturing, healthcare, and transportation, creating a smarter and better connected world.

4G is no longer enough

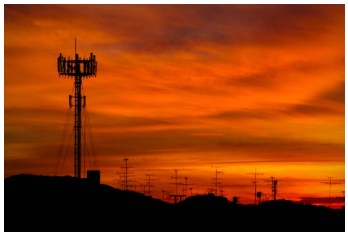
While it will bring great benefits to people's lives and society, 5G also brings huge challenges to existing networks. It requires higher transmission speeds, more bandwidth, lower delays, and wider connections – requirements that 4G transport networks cannot meet. Transport networks must therefore become more flexible and intelligent to be ready for the coming 5G era. China Unicom Beijing believes that the readiness of the transport network is critical to bringing 5G to market quickly. Therefore, infrastructure resources need to be reserved, and 5G-oriented planning and reconstruction must be completed for transport networks before reconstructing wireless and core networks.

Reserving infrastructure resources in preparation for 5G

5G also requires wireless sites to be distributed more densely, with built in support for CRAN and DRAN construction.

Therefore, before approaching 5G construction, China Unicom Beijing evaluated the infrastructure resource requirements of different construction methods on wireless, transport, and core networks.

In 2017, the operator began checking resources, such as equipment room and optical fiber resources, for each service access area. These checks allowed it to identify resource gaps and bottlenecks that would affect 5G construction. Based on its findings, China Unicom Beijing accelerated the removal of copper cables, integration of equipment rooms, and reservation of resources. It also set out a plan for infrastructure resource reconstruction.



Currently, China Unicom Beijing has reconstructed equipment rooms in pilot areas and some hotspots, gaining valuable experience that will help with subsequent reconstruction and lay a foundation for 5G commercialization.

Selecting the 4G IP RAN and 5G co-transport solution

In 2018, China Unicom Beijing launched its pilot 5G project. The ability to commercialize 5G was one of the key factors in determining what pilot solution to use. It found that the most feasible and cost effective solution was 4G based on 4G IP RAN and 5G co-transport solution.

All core and aggregation devices and more than 96 percent of access devices on China Unicom Beijing's 4G IP RAN can evolve to support 5G. In addition, it has deployed a Layer 3-to-edge solution on its live network to meets low-delay forwarding requirements. Both flexible connections and 5G time synchronization requirements can be met. For device capabilities and solution deployment, 4G IP RAN has a high degree of 5G readiness and can be used to implement 5G transport through evolution and capacity expansion.

The 4G IP RAN-based 4G and 5G co-transport solution can minimize infrastructure resource and power consumption, speed up network construction, protect 5G construction investment, and improve network O&M efficiency.

On July 28, 2018, China Unicom Beijing opened its first 5G site on Daoxianghu Road, Beijing, trialing driverless vehicles with Huawei and Baidu. It then completed service provisioning at a site in Financial Street, and verified that the network could carry both 4G and 5G services.

To keep pace with network evolution and develop strong technical capabilities in preparation for 5G , China Unicom Beijing has verified a clutch of new technologies, including 50GE on a single interface, segment routing (SR), and FlexE slicing.

Piloting Network Cloud Engine (NCE) together with Huawei

5G services drive cloudification, the downstream move of core networks, and ubiquitous connectivity. China Unicom Beijing believes that future networks must be more flexible and intelligent, and as such has piloted Huawei's NCE with Segment Routing (SR) enabled to implement agile tunnel adjustment and meet flexible 5G access requirements in the initial phase. The NCE will replace existing network management systems on the live network to power fast service provisioning, automatic site deployment, and intelligent maintenance to meet requirements for fast commercial deployment and intelligent O&M on 5G services.

Future-oriented 5G transport network planning

The pilot use of 5G is just the beginning. China Unicom Beijing is planning a target transport network that can meet requirements over the next three to five years. Planning is based on the unlimited 4G package currently in use and the requirements for 5G service development. It also takes into account the predicted service model of each service area and even each node, and considers whether existing networks and devices can meet 5G service requirements.

China Unicom Beijing will upgrade or expand the platforms at the core and aggregation layers, and upgrade or reconstruct the existing access network based on whether DRAN or CRAN is used, and whether an area is a hotspot. The pace of transport network construction will be determined by the pace of wireless network construction, ensuring that the transport network is 5G ready before the wireless network. Currently, China Unicom Beijing has completed the planning of its target 5G transport network in the main aggregation areas and formulated the implementation plan.

Building a 5G-capable Beijing

China Unicom Beijing not only researches 5G technologies, standards, and applications, but also promotes the development of 5G industries and applications, especially applications that combine production, life, society, and culture, as well as IoT service applications.

At the beginning of 2018, the operator signed a strategic cooperation agreement with Huawei. The two parties set up a joint work team to build a demo 5G network, provide intelligent communication services for the 2022 Winter Olympics, fully verify 5G solutions, incubate 5G industry applications, and attract and foster 5G talent. Since then, China Unicom Beijing's 5G strategy has been put into practice.

On August 13, 2018, China Unicom Beijing officially launched its 5G NEXT plan, covering five key scenarios and five key applications, to promote the development of the 5G industry and build a future-oriented 5G network in Beijing. The five scenarios are Beijing's sub-civic center, new airport, World Garden 2019, Winter Olympics 2022, and Chang'an Street. The five applications are autonomous driving, big healthcare, industrial Internet, smart city, and ultra HD videos.

China Unicom Beijing will continue to focus on these key scenarios and applications, and keep pushing for technological innovation that focuses on setting benchmarks and guaranteeing user experience to implement 5G for Beijing.

How 5G microwave can fast-track mobile broadband growth in emerging markets

In 2018, Huawei launched a 5G microwave mobile transport solution that can improve microwave spectral efficiency, simplify deployment and upgrades, and reduce deployment and upgrade costs.

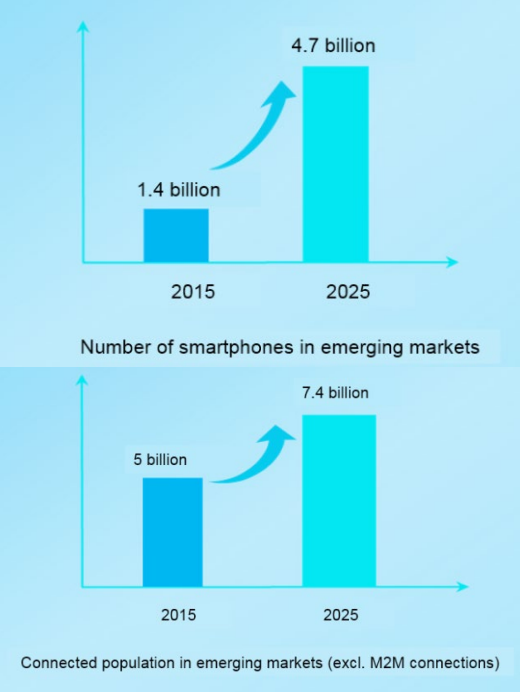
By Wang Zheng

> In 2020, the total amount of traffic in emerging markets will be seven times higher than in 2015, posing a huge challenge for network transmission and capacity.

Emerging markets have huge potential for data growth, a major factor in the fast deployment of mobile transport infrastructure

As emerging markets realize the social benefits brought by the information superhighway, many nations are developing broadband plans from a strategic perspective to speed up the deployment of fixed and mobile broadband infrastructure.

With the rapid development of new technologies and the increase in wireless network coverage and capacity in recent years, mobile traffic around the world has been growing fast. Huawei's GIV2025 (Global Industry Vision 2025) estimates that emerging markets have a greater potential for growth than developed markets. During the 10 years from 2015 to 2025, the number of smartphones will increase by two and a half times, and the connected population will increase by 48 percent to 7.4 billion.



Source: Huawei GIV2025

The CAGR of traffic in the Middle East and Africa has reached 71 percent, outpacing other regions. In 2020, the total amount of traffic in emerging markets will be seven times higher than in 2015, posing a huge challenge for network transmission and capacity.

Operators in emerging markets face more challenges than those in developed countries when it comes to network construction. These challenges are as follows:

· Outdated infrastructure, few reusable legacy resources, and CAPEX-heavy replacement.
· High construction costs for optical fiber networks and lengthy implementation, making this type of project a tough investment decision.
· Low ARPU and difficultly in developing new services, which prolongs ROI.
· Slow economic development makes revenue growth difficult and restricts investment budgets.

Because of these difficulties, operators in emerging markets need to consider all network construction factors and spread TCO over multiple years to maximize returns.

How Huawei's 5G microwave solution can help

To address the situation in emerging markets, Huawei has continuously developed transport technologies, especially for mobile transport and broadband services in scenarios where optical fiber deployment is unfeasible.

In 2018, Huawei launched a 5G microwave mobile transport solution that can improve microwave spectral efficiency, simplify deployment and upgrades, and reduce deployment and upgrade costs. The solution meets the transmission requirements of existing 2G, 3G, 4G, and home broadband services, and supports seamless evolution to 4.5G and 5G, achieving optimal TCO.

Huawei's 5G microwave solution consists of ultra-low-latency IDUs that support various interfaces, including 10GE. It provides the industry's first carrier aggregation (CA) ODU with modular antennas, and supports seamless upgrades from hundreds of Mbit/s to 10 Gbps. The solution also integrates Huawei's proprietary SDB dual-band microwave and MIMO features to allow operators to select the optimal network construction model based on application scenarios and available spectrum resources.

One operator in India, for example, upgraded its bearer network from 3G to 4G and needed to multiply microwave transmission capacity. The fastest way to do so was to upgrade the existing single-channel single-polarized transmission to XPIC dual-channel transmission. However, replacing existing single-polarized antennas is expensive and time-consuming, and compromises user experience. Huawei developed a customized upgrade solution that leverages a unique modular antenna upgrade technology. Instead of replacing the existing antennas, the solution only required the operator to replace its modules, which improved upgrade

> To address the situation in emerging markets, Huawei has continuously developed transport technologies, especially for mobile transport and broadband services in scenarios where optical fiber deployment is unfeasible.

efficiency fourfold, avoided antenna transportation and delivery costs, and reduced TCO by 60 percent.

Another operator in India was also facing pressure to expand its microwave capacity, but lacked additional microwave spectrum resources – it could only hope to improve spectral efficiency. Microwave MIMO technology can boost spectral efficiency, but because of the large spacing required between MIMO antennas, it cannot be used in some sites. Huawei's enhanced MIMO technology reduces the required spacing between MIMO antennas by two-thirds, which in turn reduces spectral costs by more than 50 percent and can be used in more than 80 percent of sites.

In the Middle East, optical network construction is both expensive and time-consuming. If operators wait for optical fiber resources to be ready, broadband programs might overrun or be delayed, which can in turn cause user churn. However, Huawei's single-antenna SDB solution offers a capacity of 10 Gbps at 7 km, and the capacity can be further improved to 20 Gbps. For the same area and distance, and to meet capacity requirements in the coming three to five years, Huawei's solution reduces investment by 40 percent and the construction period from 8 months to less than one, which helped one customer improve its market share in this area.

In southern Africa, one operator began to verify its 5G services and, to do so, selected Huawei's 5G microwave transport solution for latency-sensitive and automated control services. Using a dedicated algorithm and architecture, 5G microwave reduced latency by 50 percent, and the test results met the customer's requirements. More importantly, ultra-low latency can be achieved by upgrading existing microwave devices.

In Asia-Pacific, the Middle East, and Africa, more operators are choosing 5G microwave to build their bearer networks. The solution's ultra-high bandwidth, ultra-low latency, seamless upgrades, and significantly lower TCO are welcomed in emerging markets, with one customer in India stating that, "Huawei's 5G microwave solution is future-oriented and can support the long-term evolution of our bearer networks."

In the future, Huawei will continue to work closely with global operators to enhance the capabilities of 5G microwave solutions and help global operators, especially those in emerging markets, build mobile broadband networks that are future-oriented and represent the best use of CAPEX. In this way, everyone can share in the dividends of global network development.

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