OCT 2018 | VOL. 20 • NO. 5 • ISSUE 178

ZTE TECHNOLOGIES

VIP Voice

Getting Prepared for 5G Commercialization

Expert Views

Building an Access Office in the 5G Era

Special Topic: Fixed-Mobile Convergent Access

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Success Story

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Getting Prepared for 5G Commercialization

Reporter: Sun Dong

Bai Yang, CTO of ZTE Asia & CIS Region

During 5G Asia 2018 held on September 18–20 in Singapore, Bai Yang, CTO of ZTE Asia & CIS Region, talked to *ZTE Technologies* about the 5G development in Asia Pacific and ZTE's role in the region's emerging 5G landscape.

What do you think of Asia Pacific's 5G development as compared to the rest of the world?

More than half of the world's mobile subscribers are in Asia Pacific, which also includes the world's two biggest mobile markets, China and India. Asia Pacific has seen a rapid growth of 4G services due to extensive 4G deployments in the region. China, Japan, South Korea, and Australia have completed lots of 5G verification tests based on existing networks and will be the first countries to commercialize 5G services by 2019. It is expected that led by these pioneering countries, Asia Pacific will be the largest 5G region in the world by 2025, and lead in the development of 5G ecosystem.

What's ZTE's current focus in Asia Pacific?

Asia Pacific is always our most important overseas market. Indonesia, India, Japan, Myanmar and Thailand are five biggest markets in this region. Vietnam and Philippines, two densely populated and rapidly developing countries, are also important markets that we'll expand into. With 20 years of presence in the Asia-Pacific telecoms market, we have established long-term strategic partnership with major carriers like SoftBank, SingTel, Bharti Airtel, Ooredoo, Hutchison, and of course, three Chinese carriers. We have been their most reliable partner and guide for technology innovation. From a product perspective, we focus on future-oriented technologies like 5G/Pre5G, optical transmission and access, and SDN/NFV in this region.

What kind of role is ZTE playing in Asia Pacific's 5G development?

Taking 5G development as its core strategy, ZTE establishes leadership in the commercialization, the core technologies and the economies of scale for 5G. ZTE, in close cooperation with China Mobile, AIS and other mainstream carriers, has deployed a series of 5G trial networks to get prepared for 5G commercialization.

With complete product lines, ZTE can provide end-to-end 5G solutions covering wireless, core network and bearer network. ZTE holds lots of 5G-related core patents. As the first drafter of nonorthogonal multiple access (NOMA), ZTE led the adoption of NOMA by the 3GPP RAN Working Group 1. Another core technology multi-user shared access (MUSA) proposed by ZTE is also expected to become a 5G standard.

TDD-LTE lays the basis for 5G. ZTE's TDD shipments have, for four consecutive years, accounted for one third of the world's total, which lays the foundation for 5G's advanced commercialized use and cost savings. China Mobile has deployed more than 3 million 4G base stations across China. As China Mobile's major 4G supplier, ZTE will deploy a large-scale 5G network for them in the next two years, which could effectively lower the cost of 5G products.

In addition, ZTE has actively participated in many standardization bodies such as ITU, 3GPP and IEEE. It has also joined organizations such as the 5G Automotive Association to explore 5G applications with industry partners, and cooperated with many top universities around the world to build 5G research centers. We can say that ZTE is leading the way to 5G.

Could you give us some concrete examples about how ZTE is helping operators transform

their networks in preparation for 5G in Asia Pacific?

ZTE plans to complete pre-commercial deployment of 5G by the end of 2018, and scaled deployment of 5G in first half of 2019. ZTE has established 5G partnerships with over 20 top operators around the world, providing products and services for the world's first 5G commercial deployments. Among them, China Mobile is the strategic partner that ZTE has cooperated for the longest time.

As early as the first half of 2016, ZTE has already deployed Pre5G Massive MIMO products for China Mobile in 30 provinces in China. Subsequently, the two companies jointly established a 5G Joint Innovation Center to perform tests and verifications of 5G end-to-end solution and products. In June 2017, ZTE established China's first 5G pre-commercial base station in Guangzhou for China Mobile, achieving peak data rates of over 2 Gbps for a single UE. In November 2017, ZTE and China Mobile jointly completed field tests of continuous coverage of multiple base stations, which is very close to meet commercial network requirements. In December 2017, ZTE got one-third share of China Mobile's NB-IoT project. In April 2018, ZTE and China Mobile made the first 5G call compliant with the 3GPP R15 standard, formally launching the field site for an end-to-end 5G commercial system. In terms of 5G applications, ZTE and China Mobile together joined Baidu's Apollo Program to verify the application and key technologies of autonomous driving. ZTE will achieve the first commercial 5G deployment with China Mobile and extend its successful experience to other operators around the world.

What are the major challenges in Asia Pacific in the path towards 5G?

In some countries, such as India, Indonesia and Thailand, due to fierce competition in the telecommunications market, carriers' profits have been declining, and their willingness to invest in new technologies has decreased, which is not a positive trend. As can be seen from 4G deployments in the last few years, the carriers who deployed 4G first in the country, such China Mobile, has achieved huge first-mover advantages and seized a large number of users, especially high-value users. Carriers should be actively involved in 5G testing, and deploy small-scale 5G trial networks in hotspots or large cities with controllable investment, to get prepared for commercial 5G deployment.

How can ZTE better help operators cope with these challenges?

ZTE can provide end-to-end 5G solutions and mature, commercial-ready 5G products, and has rich 5G pre-commercial experience. ZTE is willing to provide consulting services for operators and develop customized 5G evolution solutions based on their networks. For operators that are still working on large-scale 4G rollouts, ZTE's 4G and Pre5G products support the smooth evolution to 5G without causing investment waste. In addition, compared to traditional networks, ZTE's SDN/NFV-based virtualized core network and transmission network can reduce the costs and the service commissioning time. ZTE's leading GPON products and big video platforms can reuse existing network infrastructure, helping traditional operators enter a huge new market with a small investment, and realize full-service transformation.

What's your expectation for ZTE's growth in the Asia-Pacific market?

As a company that actively embraces change, ZTE is devoted to research and development of innovative technologies and deployment of products and solutions. For the Asia-Pacific region, ZTE aims to seize the opportunities offered by strategic products including 5G, beyond 100G, and SDN/NFV, and become a leader in 5G by continuously optimizing its strategic layout regarding customers and products. ZTE TECHNOLOGIES

Chen Aimin
Chief Engineer for Optical Access Planning, ZTE

Building an Access Office in the 5G Era

By Chen Aimin

Challenges Facing Access Offices in the 5G Era

The access office (AO) is the telecommunications equipment room nearest to end users. It houses OLTs and typically covers broadband users in a 3 to 5 km radius. In the 4G era, BBUs are usually pooled, and operators tend to deploy a large quantity of BBUs in their AOs to reduce the number of equipment rooms. Although wireline and wireless devices already share an AO in the 4G era, wireline and wireless are independent of each other in terms of service and network.

Typical application scenarios defined for 5G include enhanced mobile broadband (eMBB) with peak data rates of up to 10 Gbps, massive machine-type communication (mMTC) characterized by a density of one million connections per square kilometer, and ultra-reliable low latency communication (uRLLC) with a low latency of 1ms required for such applications as the internet of vehicles (IoV). 5G will enable the internet of everything (IoE), where humans, machines and the environment will be more closely and efficiently linked, and there will be continuous innovation of the production modes, business models and people lifestyles. Network service provision will be based on services instead of access modes because whether access is wired or wireless will be irrelevant to users. Service integration is bound to drive network convergence.

To ensure the delivery of rich services and applications, the 5G network employs a brand-new architecture:

- The 5G core network uses a cloud-based architecture that separates control and forwarding functions and allows for fast deployment of services as needed. The introduction of multi-access edge computing (MEC) technology pushes service processing closer to the edge and reduces latency. A unified 5G core network provides mobile users with consistent services and enables fixed-mobile convergence (FMC), thereby ensuring a seamless service experience across wireline and wireless scenarios.
- The 5G access network adopts an architecture where the AAU, DU and CU are separated, and the practice of distributing AAUs and pooling DUs is still heavily used. The introduction of high-frequency base stations vastly increases base station density. The scale and complexity of the fronthaul network is substantially expanded, which presents an unprecedented fiber resource consumption challenge.

As the access portal for users in the 5G era, the AO must offer super-high bandwidth, ultra-low latency and differentiated QoS assurances, as shown in Fig. 1.

More importantly, it has to accommodate dynamic connections brought by cloudification of the 5G core network. The introduction of MEC can move some of the service processing to the NFV infrastructure (NFVI) of the AO. Moreover, the traffic inside the AO between the wireline and wireless services and between the NFV services on the NFVI also surges. Faced with these 5G requirements, traditional AO architecture falls short and needs a transformation.

Objectives of Access Office Construction in the 5G Era

The AO for the 5G era will be an intelligent FMC equipment room that is superfast, easy to maintain, flexible, and reliable. While the existing power supply system (including power backup equipment), cooling system, monitoring system and wiring routes of the AO are kept intact, its internal network is divided into four functions as shown in Fig. 2:

- Connection function: Using a leaf-spine data center topology, the AO can build a high-bandwidth, scalable and reliable internal communication network to support complex communications among the DU (wireless), OLT (wireline), uplink transmission equipment, and NFVI with QoS assurance.
- Access function: The DU is used for wireless access processing, while the OLT for wireline access processing.
- NFVI (computing and storage function): The NVFI is deployed in the AO to ensure that low-latency, real-time services can be rapidly processed to improve user experience. Because the NFVI provides computing and storage capabilities, it can be seen as a remote module of the edge data center (EDC) and the NFV services running on it are centrally orchestrated and managed by the 5G core network.
- Transport function: The AO provides network-side interfaces to centrally carry wireline and wireless traffic from the OTN, IPRAN or SPN equipment.

Principles of Access Office Construction in the 5G Era

Since AOs exist in large numbers and vary greatly in their hardware conditions and environments, transforming all of them in one stroke will incur an enormous workload and a huge investment. Instead, they should be evolved step by step based on the following principles:

- Openness: The interfaces among access function, connection function, NFVI (computing and storage function) and transport function should be open. The NFVI is shared by all the functions and users of the AO.
- Scalability: AOs vary significantly in their hardware conditions including the floor area, power supply system and cooling equipment. The access, connection, computing & storage, and transport equipment in the AO can be trimmed according to service needs and smoothly expanded as per

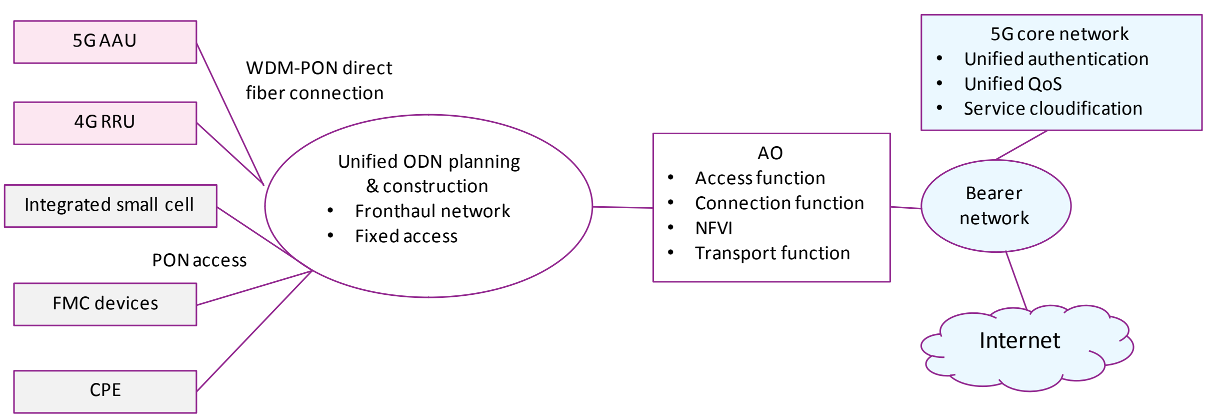

Fig. 1. AO as the portal for wireline and wireless access in the 5G era.

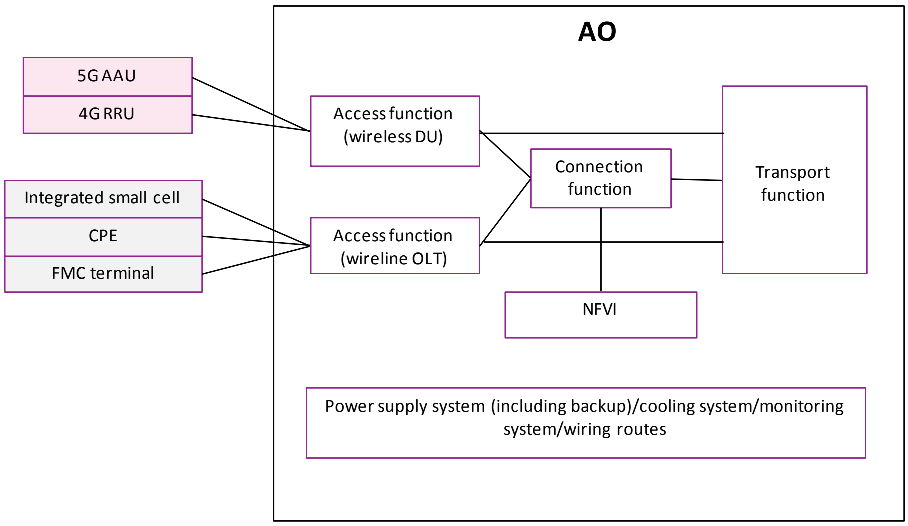

Fig. 2. Logical architecture of the AO in the 5G era.

functionality and capacity.

- Flexibility: The reconstruction of the AO should be based on smooth evolution of the AO's existing architecture. Functions can be flexibly deployed according to the conditions of the AO and without affecting the operation of the existing services.

Steps of Access Office Construction in the 5G Era

Considering the above-mentioned principles, we suggest building an AO in three steps, which can be merged or adjusted if needed:

- Step 1: Setting up an NFVI: Low-latency, real-time NFV services of the 5G era need to be deployed as close to end users as possible. To achieve this aim, the NFVI and the internal communication network supporting the NFVI have to be installed in the AO. The NFVI, as a remote module of the EDC, is managed and controlled by the EDC, and enables service deployment under centralized orchestration of the 5G core network, thereby ensuring a smooth switchover of services and consistent user experience across wireline and wireless. Such services include video acceleration, location service, and TCP acceleration.
- Step 2: Smartening up the AO: The access, transport and connection functions of the AO are centrally managed to separate equipment management and service management. Service management by incorporating SDN&NFV can enable fast end-to-end deployment as well as intelligent operation and maintenance.
- Step 3: Integrating and optimizing the AO: The access function, transport function, connection function, and NFVI (computing and storage function) of the AO are performed by separate devices. To save space, simplify deployment, boost reliability and provide QoS assurances for different services, related functions can be integrated to reduce the number of network elements. The AO can also be optimized using a standard module. The module can selectively house access, connection and transport functions while at the same time solving cooling and monitoring issues. After being tested and verified in the factory, the module can be directly installed in the AO to cut the engineering workload. By adding modules as needed, the AO can be conveniently expanded to keep up with service demands.

The numerous AOs are an important asset of operators. With the trend towards FMC, operators should modernize their AOs in stages so that the AOs can support full-service bearing, smart operation, centralized management, fast service deployment, and smooth scalability. Only through such modernizations can the business value of the AOs be fully tapped in the 5G era. ZTE TECHNOLOGIES

Research on 25G WDM-PON

Bearer for 5G Fronthaul

Li Yufeng
Chief Engineer for FN Product Planning, ZTE

By Li Yufeng

Development Progress

Wavelength division multiplexing passive optical network (WDM-PON) combines the WDM technology and PON topology structure to provide high bandwidth, low latency, fiber savings, plug-and-play optical network units (ONUs), simple OAM, and low costs. Thanks to these strengths, WDM-PON is uniquely suited to 5G fronthaul applications and has attracted widespread industry attention in recent years.

The ITU-T G.9802 standard defines the universal requirements of wavelength routed/wavelength selective (WR/WS) PON application scenarios as well as those of wavelength allocation, tuning and management. In 2015, ITU-T Q2 defined the indices of 8-wavelength point-to-point (PTP) WDM in 989.2 Am1—a specification on the physical media dependent (PMD) layer of 40-Gigabit-capable passive optical networks 2 (NG-PON2). WDM-PON requires mature and reliable OAM mechanisms. Annex B of 989.2 Am1 defines the auxiliary management and control channel (AMCC) to transport wavelength allocation information and OAM data, thereby achieving wavelength control and transparent service transmission for WDM-PON. Annex C of 989.2 Am2 defines the network architecture and optical layer indices of WR WDM-PON, with the modulation rate specified as 10 Gbps.

International standards for 25G WDM-PON have not been released, but discussions are already under way. To meet the need of higher bandwidth for 5G fronthaul, ITU-T Q2 has begun to work on a technical white paper about using single-wavelength 25G WDM-PON for 5G fronthaul. The research on efficient fronthaul network architecture that produces breakthroughs in high-speed colorless ONU and AMCC technologies is key to speeding up the industrialization of WDM-PON standards. In 2014, ITU-T SG15 initiated the G.metro standardization work, which was led by China Unicom and involved active participation of mainstream operators and vendors. The standard that was finalized in February 2018 as G.698.4 V1.0 defines the 20-/40-wavelength 10G interface and focuses on a 20 km transmission distance. G.698.4 will undergo more revisions in the future to upgrade its interface support to 25G and higher rates.

In China, the China Communications Standards Association (CCSA) has initiated a WDM-PON project and is expected to release the relevant standard in Q3 2018. As for enterprises, China Telecom started

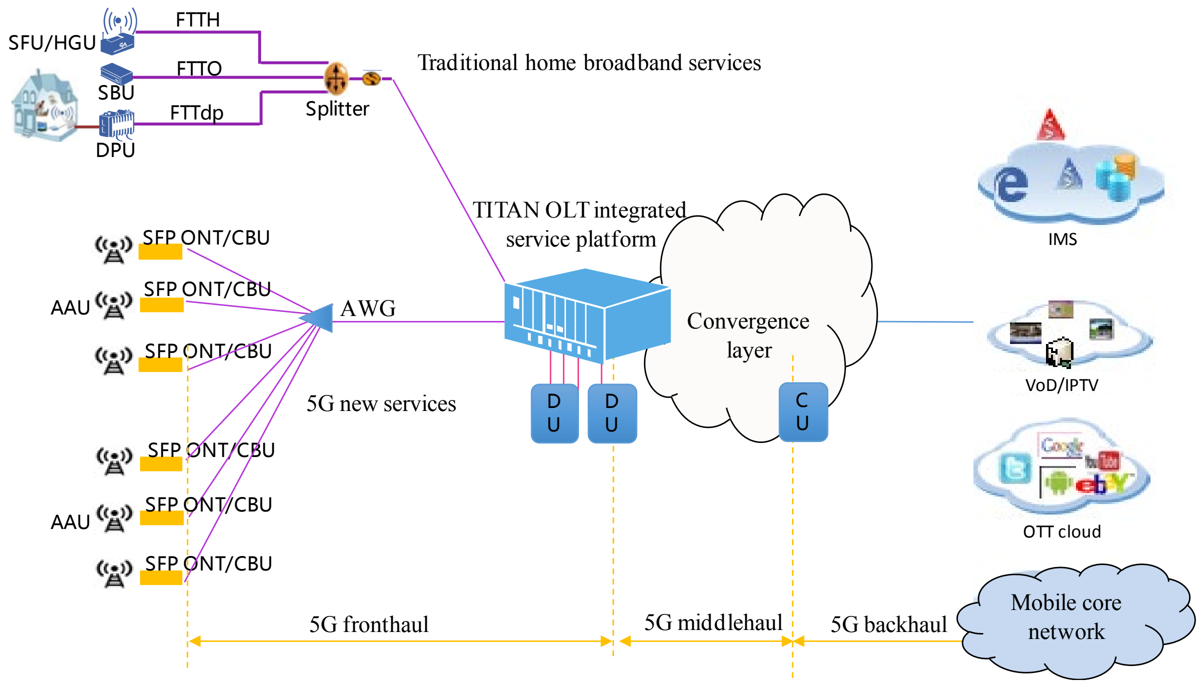

Fig. 1. The network architecture of WDM-PON 5G fronthaul based on TITAN OLT.

related standards formulation in Q2 2018 through its Shanghai Research Institute, while China Unicom plans to publish its 25G WDM-PON standard at the end of 2018.

As an important supplementary solution for 5G fronthaul, 25G WDM-PON is forecast to commence large-scale commercial trials in 2019 to 2020.

Technological Analysis

In 5G greenfield or hotspot scenarios, operators face pressure to reduce the number of sites and leased equipment rooms. The capital expenditure (Capex) on sites and equipment rooms can be significantly cut through centralized deployment. Consequently, employing centralized radio access network (C-RAN) architecture for 5G fronthaul has found great favor with operators. WDM-PON OLT can take advantage of the access office (AO) to enable the deployment of a centralized distributed unit (DU) pool. When conditions permit, wireline and wireless AOs can be co-located. The WDM-PON architecture is based on a point-to-multipoint tree topology of passive optical networks and therefore can vastly cut the fiber resources required. It can also use the idle fiber resources of the existing ODN to reduce network construction and maintenance costs.

WDM-PON is a high-performance access scheme that leverages advantages of the WDM technology and PON topology structure. WDM-PON does not permit bandwidth sharing among users and hence is the best solution to handle a surge in bandwidth demand. Compared with existing mobile fronthaul technologies such as dark fiber, passive WDM and active dense wavelength division multiplexing (OTN, DWDM), WDM-PON has numerous advantages including high bandwidth, low latency, fiber savings, plug-and-play ONUs, simple OAM, and low costs. These advantages make it better for WDM-PON to satisfy 5G fronthaul requirements such as dense site deployment, growing bandwidth needs, and shorter latency.

In January 2018, 3GPP released the first version of Ethernet common public radio interface (eCPRI) specification for 5G fronthaul. 25G eCPRI has been basically designated as the 5G fronthaul interface, and 25G single channel will be a mainstream interface for 5G fronthaul. 25G WDM-PON is the perfect enabler of such an interface.

ZTE has been researching WDM-PON technology since 2010. Collaborating with China Telecom and the Chinese broadcast and TV sector, ZTE conducted research on 64-wavelength 10G WDM-PON equipment and applications, which was supported by China's 863 Program. In 2014, ZTE launched demonstration networks in Wuhan and Shanghai to offer converged services such as internet access and high-definition video for thousands of users. In January 2018, ZTE was among the first vendors to complete development and testing of 10G WDM-PON equipment that met the fronthaul device interface requirements of China Telecom's 5G trial in Shanghai. According to the plan, ZTE will also verify the delivery of wireless services through 5G base stations on the existing network.

ZTE has launched its TITAN access platform for 5G fronthaul. The platform provides high-density 25G WDM-PON cards and addresses technical challenges of low-latency forwarding and high-precision time synchronization for 5G fronthaul. Because TITAN is deployed in the AO, it can provide a unified 5G bearer solution for fronthaul, middlehaul and backhaul. The network architecture of WDM-PON 5G fronthaul based on TITAN OLT is shown in Fig. 1.

> ZTE has launched its TITAN access platform for 5G fronthaul. The platform offers high-density 25G WDM-PON cards, addresses technical challenges of low-latency forwarding and high-precision time synchronization, and provides a unified 5G bearer solution for fronthaul, middlehaul and backhaul.

ZTE's WDM-PON 5G fronthaul solution has the following technical advantages:

- It supports CPRI and eCPRI standards as well as 4G/5G hybrid networking.
- It has high bandwidth that supports 25G per channel and can smoothly evolve to single-wavelength 50G in the future.
- It has high density, with a single trunk fiber providing an access capacity of 20×25G.
- It provides exclusive bandwidth for a single wavelength, high transmission efficiency, and abundant bandwidth resources.
- It provides colorless ONU technology that can be used for flexible wavelength allocation and wavelength routing.
- Its future colorless small form-factor pluggable (SFP) ONU can be directly inserted into the active antenna unit (AAU) to improve equipment integration.
- Its arrayed waveguide grating (AWG) has smaller loss than power splitter. The loss is about 5.5 dBm.

The WDM-PON 5G fronthaul solution allows for sharing of the existing fiber infrastructure. While a 5G network needs a lot of fiber resources, the architecture based on the point-to-multipoint tree topology of a PON can save large amounts of trunk fibers. The existing FTTx networks are big in size with rich line and port resources. A full use of these resources can reduce 5G network deployment costs, avoid overlapping investment and increase existing network utilization while improving network coverage.

The WDM-PON 5G fronthaul solution also allows for sharing of the AO resources by wireline and wireless access. The re-architected AO, in particular, can make the most of the solution in integrated network construction and sharing investment. After

DUs are pooled, wireless and OLT resources can be shared and built as needed. OLT can serve as the shared equipment or platform for both wireline and wireless services. Both the OLT platform and the DU pool can be deployed in the same AO to remove the operator's dependence on sites and rooms and shrink their auxiliary equipment and site costs as well as energy consumption.

Besides, the solution also allows one OLT to deliver multiple services, providing unified access to home users, government/enterprise users, and 5G base stations. This further enhances equipment utilization, saves network deployment costs and reduces the number of sites and rooms being used.

Prospects

Photoelectric devices in a WDM-PON system are cutting-edge and highly sophisticated and require the high-end integrated photoelectric chip R&D and manufacturing capabilities. Mastering the core technologies of optical sources is essential to bringing WDM-PON to fruition.

25G optical receivers such as positive-intrinsic-negative (PIN) photodiodes and avalanche photodiodes (APDs) have matured, with some of them already in large-scale commercial use. 25G tunable laser is an important 25G WDM-PON component. The wavelength tunable ONU technology is based on the tunable laser and can easily implement high-speed transmission when integrated with the modulator. Currently, there are many types of tunable lasers supplied by a variety of vendors, but their rates have not yet met the requirements for 5G fronthaul. Although the digital supermode-distributed Bragg reflector (DS-DBR) has obvious advantages among the tunable lasers in terms of tuning range, integration, modulation rate and technology maturity, its cost is relatively high. Of many technical schemes proposed for tunable lasers, the combination of DS-DBR and Mach-Zehnder modulator (MZM) is the most mature and expected to achieve a transmission rate of 25 Gbps in 2018. Compared with DS-DBR, other schemes are more cost-effective and have a brighter future after addressing the issues like transmission rate, tunable range and optical power.

In general, the 25G WDM-PON industry chain is basically mature but still needs sustained investment in chips, modules, equipment and systems to develop key technologies, reduce the cost of core devices, establish unified standards, and accelerate the productization process.

Fixed Mobile Convergent Access in the 5G Era

By Li Yufeng

Li Yufeng
Chief Engineer for FN Product Planning, ZTE

Background of FMC Development

Fixed mobile convergence (FMC) allows fixed and mobile networks to interwork for convergent and full service operation. The FMC technology provides users with diverse quality services including communications, information and entertainment, independent of the terminal, network, application and location.

Mobile broadband and fixed broadband both compete and rely on each other. In areas such as internet access and data service, mobile broadband replaces some of the fixed network functions. For example, smartphones have gradually taken the place of fixed terminals including computers as the primary mode of accessing the internet. Mobile and fixed networks are also interdependent. A heterogeneous network based on cellular and cloud-RAN (C-RAN) technologies requires a large amount of mobile backhaul networking. In the access segment, in particular, mobile and fixed networks both need a great deal of optical infrastructure.

As competition intensifies in an increasingly mature telecom market, operators are compelled to find ways to prevent customer churn and attract new users. Since 2012, some operators in Europe have gained more mobile or fixed users by engaging in mergers and acquisitions (M&A) and tapping the potential of existing users. Notable cases include the acquisition of British mobile operator EE by incumbent fixed-network operator British Telecom (BT) and the success of Deutsche Telekom (DT) in signing up 70% of its mobile users to its fixed broadband services. FMC has become an effective means used by operators in their battle for users.

In the LTE era, an IP multimedia

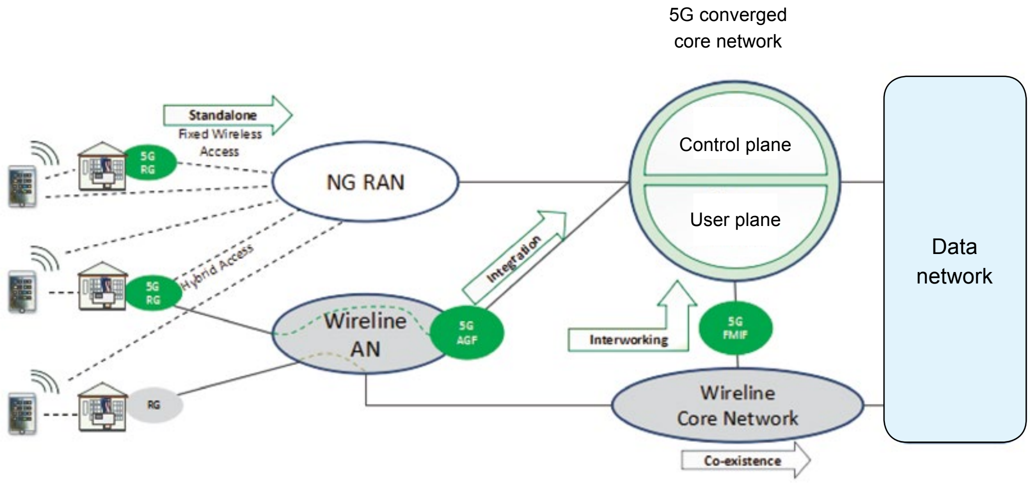

Fig. 1. FMC architecture in the 5G Era.

subsystem (IMS)-based FMC solution can provide fixed and mobile users with unified voice, data and video services to improve quality of experience (QoE). By adopting the new operating model of binding fixed and mobile users, operators can retain customers, boost average revenue per user (ARPU) and improve profitability.

In the 5G era, in-depth convergence of cloud network architecture, virtual network functions (VNFs), and service functions brings new opportunities and challenges for FMC.

Analysis of Application Scenarios and Technical Architecture

FMC services need to have the following characteristics:

- Seamless connection is set up between the equipment and network layers, allowing diverse applications to be transported between different network platforms. Handover between different networks does not interrupt or degrade quality of service (QoS).
- Various user access modes are supported. Converged services and devices can select different access modes such as Wi-Fi or cellular networks according to the user location, required application, QoS and voice traffic.
- Users can use one terminal rather than previous multiple terminals to implement all applications.
- Personalized services are supported. End users can set services and interfaces as desired. Fixed networks also support diverse settings like smartphones.

User equipment (UE) in the 5G era falls into two types: 5G RG and NG UE (Fig. 1). 5G RG is an upgraded version of the traditional RG and is connected as a UE to the 5G core network through a fixed or mobile network. 5G RG can be connected to the core network via fixed wireless access (FWA) or hybrid links. NG UE is an upgraded version of the original UE and is connected to the 5G core network through WLAN or cellular networks. NG UE can be connected via Wi-Fi or cellular networks to offload some traffic, or via both WLAN and cellular networks. In both cases, RG serves as a trusted node to provide Wi-Fi access.

From the perspective of fixed access node or access network for user terminals, 5G FMC involves architecture convergence and function convergence in the access network.

Resource Sharing and Architecture Convergence

In the 5G era, scenarios such as dense urban or hotspot areas need to adopt C-RAN architecture where DUs are centrally deployed. For fixed network access, the distance from the DU pool to the user is basically the same as that from the access office to the user. In areas where the access office has ample resources, fixed and mobile equipment can be co-located so that the resources can be shared to reduce Capex. The existing fixed network resources including the access office, power supplies, air-conditioners and transmission equipment can be shared, which facilitates the centralized equipment management (Fig. 2).

Network Simplification and Function Convergence

Network architecture, operation and maintenance can be simplified to reduce Opex. The overlapping part of authentication, control and management functions of the fixed and mobile networks are converged to provide users with consistent service experience and boost network operation and maintenance. After convergence, the fixed and mobile networks can provide:

- Standard interfaces: The 5G core network becomes more functionally independent. It is decoupled from access modes and gradually transforms into an agnostic architecture. By reducing AN-CN interface coupling, seamless and agnostic access can be achieved.
- Unified authentication: Previously fixed and mobile users were authenticated by different operating systems. The FMC architecture allows the users to be authenticated by one operator. This saves network resources and simplifies the management.
- Unified resource management: With virtualization and programmable technologies, some overlapping functions of the fixed and mobile networks can be abstracted and converged, and the operator's resources can be orchestrated in a unified manner.

There are three typical 5G FMC access modes currently being discussed by the standards bodies 3GPP and BBF, aiming to converge functions and simplify the network (Fig. 1).

- Integration mode: The access gateway function (AGF) is provided at the access node and can be directly connected to the 5G CN. Key modules include 5G RG and AGF.
- Interworking mode: In the existing access mode, the transmission equipment (such as BNG) that interconnects with CN supports fixed-mobile interworking function (FMIF) interface. Key modules include FN-RG and FMIF. The FN-RG is a traditional RG that can provide Wi-Fi access.

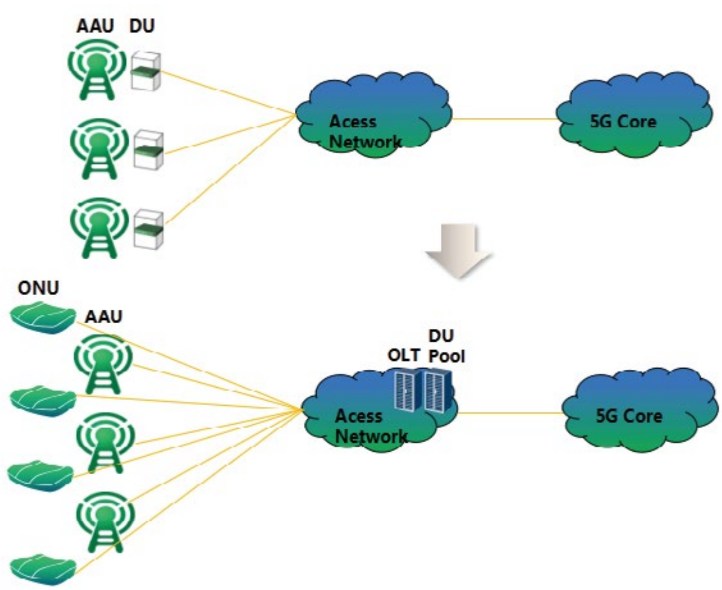

Fig. 2. New 5G architecture enables convergence of fixed-mobile resources.

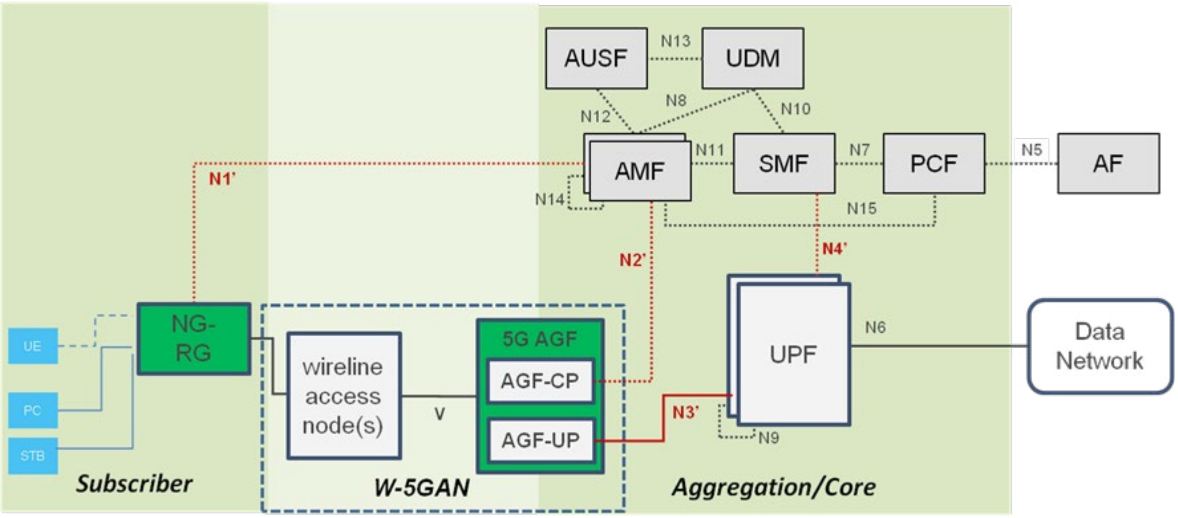

Fig. 3. Interfaces between 5G AN and core network in the integration mode.

- Hybrid mode: Fixed access and cellular access co-exist in this mode.

Of the three modes, integration is the most recommended mode because its network has the simplest architecture. As L3 is moved down to the access node, the control and user plane interfaces to 5G CN are more direct, which reduces the amount of intermediary transmission equipment.

Re-architected access office (AO) makes it easier to deploy future SDN and NFV services such as 5G AGF. In terms of functionality and location, 5G AGF will best run on the NFVI of the access office. That enables the NFV platform in the re-architected AO to be fully used to implement in-depth architecture and function convergence required by FMC.

In the integration mode, all mobile users are connected via wired access, and are provided with converged 5G CN functions. The N1'/N2'/N3'/N4' interfaces in Fig. 3 are interfaces between wired AN and core network. All mobile devices are connected to NG-RG (also called 5G RG), where user access to the core network is authenticated. The core network only needs to authenticate and charge NG-RG, without authenticating and charging individual mobile devices connected to NG-RG such as UEs, PADs, and PCs.

Industry Development and Network Evolution

FMC has attracted widespread attention in the industry. The operators that have engaged in discussions on 5G FMC standards at 3GPP and BBF are AT&T, BT, China Mobile, DT, KT, NTT, Orange, Telecom Italia, Telefonica, Telenor and Vodafone. They all have both fixed and mobile network resources.

The research paper on 5G FMC standardization at BBF is *SD-407: 5G Fixed Mobile Convergence Study,* while the research at 3GPP is included in Release 15 SA2 TS23.706. The research and cooperation at 3GPP corresponding to the Release 16 timetable will soon kick off.

The evolution target of FMC networks in the 5G era involves implementing agnostic access with a non-3GPP access network based on the 5G core network, making 5G networks more flexible with modular software and software-driven function development, supporting new 5G use cases in the industrial, public and user networks with the future-proof architecture and design, and converging more access network services with a converged cloud-based network platform.

The 5G FMC architecture is still being discussed. Many issues need to be resolved with input from operators and vendors, which will promote the continuous improvement of the 5G FMC solution. ZTE TECHNOLOGIES

Access Network Convergence Solutions

By Chen Aimin

Chen Aimin
Chief Engineer for Optical Access Planning, ZTE

Trend Toward Access Network Convergence

After ten years of high speed development, optical broadband access has expanded from traditional home broadband into other fields. Driven by big video, 5G services, and SDN/NFV evolution, optical broadband access has reached a new development stage with the ultimate goal of fixed-mobile convergence (FMC).

With the development of 4K/8K HD video services, home broadband is moving from the traditional 100M era to the 1G era. Hence, the deployment of 10G PON has become a focus of attention. High bandwidth requires large-capacity central office equipment. New-generation OLTs basically match convergence equipment in switching capacity and slot bandwidth, and it is inevitable that the OLTs will integrate with the convergence equipment.

5G that could achieve much higher speeds than 4G is nearing commercialization. 5G will provide the internet of everything (IoE) connectivity that is ubiquitous, convenient, fast, smart and reliable, which will trigger a revolution in production modes, business models and people lifestyles. Network service provision will be based on services instead of access modes because whether access is wired or wireless will be irrelevant to users. Service convergence is bound to drive network convergence, which in turn will lead to equipment integration.

Furthermore, network architecture is becoming increasingly flat and simple, which requires the access equipment to be integrated for centralized management. Meanwhile, the maturity of SDN/NFV also drives a profound transformation of the network architecture. A wireline network including optical access needs to conform to this trend, which necessitates adjustments to equipment form factors.

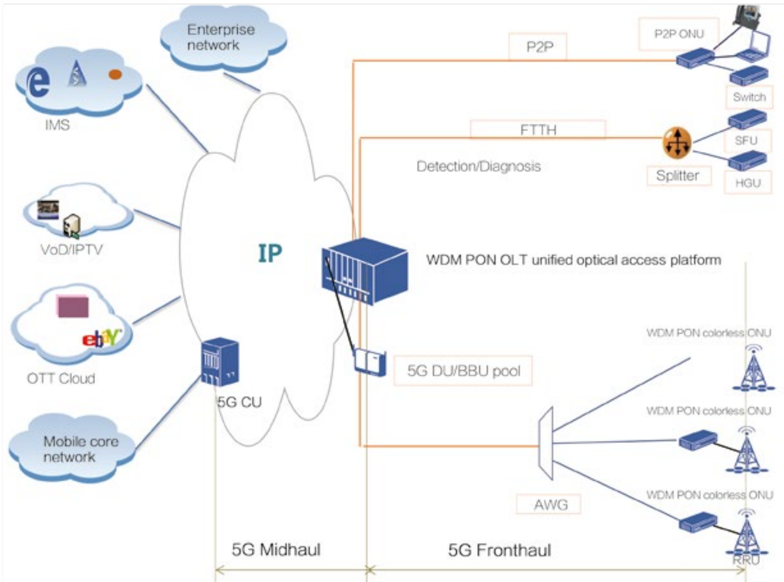

Fig. 1. TITAN-based WDM-PON fronthaul networking solution.

For access offices where space, power consumption and performance restrict each other, integration of access and other equipment is inevitable.

TITAN-Based Integrated Access Solutions

ZTE's TITAN is designed to accommodate access network development trends and help operators implement service convergence. Based on a high-end router platform, it converge with products like PTN, high-end router, and OTN in terms of architecture, allows mixed insertion of cards, and supports built-in X86 blade servers. Different integrated products can be rapidly launched to meet operators' network re-architecture needs.

In addition to the traditional fixed access services, TITAN also offers multiple convergence solutions for the 5G era including 5G fronthaul and backhaul, built-in CDN, built-in BNG and built-in OTN, to fulfill the requirements of high bandwidth, low latency and differentiated QoS.

TITAN-Based 5G Fronthaul

A WDM-PON architecture uses a point-to-multipoint tree topology to save massive amounts of fiber or uses the idle fiber resources of the existing PON to reduce network construction and maintenance costs. Fig. 1 shows a TITAN-based unified 5G optical access platform. The 5G DU pool and AAU are connected through the WDM-PON to fronthaul mobile services. This solution supports management of transparent service transmission.

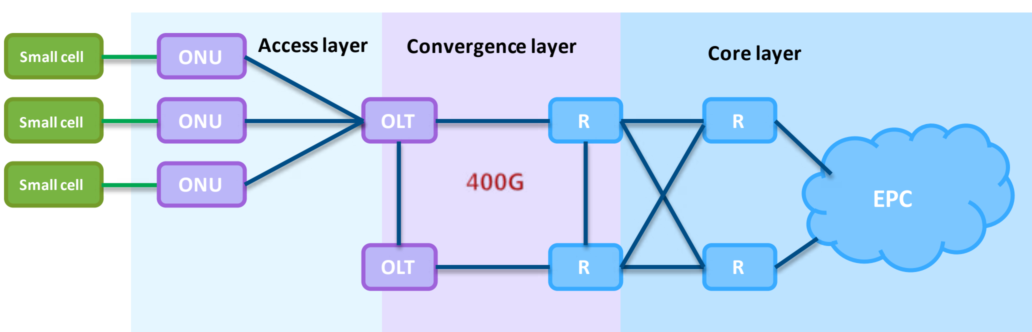

Fig. 2. TITAN-based 5G small cell backhaul solution.

The TITAN OLT unified optical access platform can be deployed according to the specific field conditions. If conditions permit, the wired and wireless access offices can be co-located. A dedicated OLT-based fronthaul network can be built when large fronthaul capacity is required.

The TITAN-based WDM-PON 5G fronthaul network architecture has several features. It supports both CPRI and eCPRI standards as well as 4G/5G hybrid networking, and provides large bandwidth with 25 Gbps per channel (smooth upgrade to 50 Gbps per wavelength in the future). It also features high density, with an OLT card providing 16 wavelength channels and a single backbone fiber offering 16×25G access capability. Multiple wavelengths are first converged by an AWG and then distributed to branch fibers, thus saving substantial backbone fiber resources.

TITAN-Based 5G Backhaul

Compared with 5G fronthaul, 5G backhaul has lower bandwidth and latency requirements. Especially, 5G low-frequency integrated small cells with high density deployments require less than 5 Gbps bandwidth. TITAN uses the TDM-PON to carry the small cell backhaul traffic, which can reuse an operator's existing ODN (Fig. 2). As the TDM-PON develops and bandwidth demand increases, 10G PON technology has matured and higher-rate 50G PON technology will be introduced. In actual deployments, small split ratios such as 1:8 can be selected and, in light of the user traffic concurrency rate, a single PON port can be used to serve multiple 5G small cells, to substantially reduce operator Capex.

5G backhaul equipment needs complete L3 functions and IP FRR-based service protection functionality. The new-generation TITAN OLT adopts a fully distributed router-style hardware architecture and basically matches IPRAN equipment in capabilities. In the future, TITAN will support such technologies as segment routing and smooth migration to SDN, allowing forwarding and control separation, cloud-based control plane, and open APIs for rapid service deployment and automated O&M. Moreover, the TITAN with a support for network slicing can realize service isolation and domain-based management.

TITAN's Built-in BNG

In the cloud-based BNG solution, the BNG control plane runs in a cloud, while the BNG forwarding plane is moved to the TITAN. This mechanism integrates the OLT with the traditional BNG forwarding plane and avoids the deployment of dedicated BRAS equipment for a forwarding plane, thus flattening the network and reducing the network cost (Fig. 3). These two planes can be implemented using interfaces such as OpenFlow (OF) and Netconf. When control is decoupled from forwarding, the control plane can be based on a universal hardware platform, helping operators reduce investment and O&M complexity. The forwarding plane is controlled centrally by an SDN architecture. An SDN controller, which integrates management and control functionalities, and a service orchestrator are deployed to enable end-to-end automatic network configuration and opening up of network capabilities.

TITAN's Built-in A-CDN

As shown in Fig. 4, a CDN edge node, called an

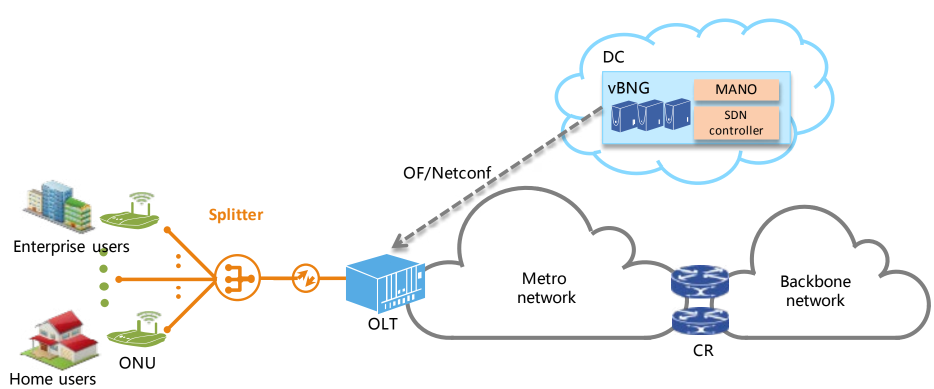

Fig. 3. TITAN's built-in BNG solution.

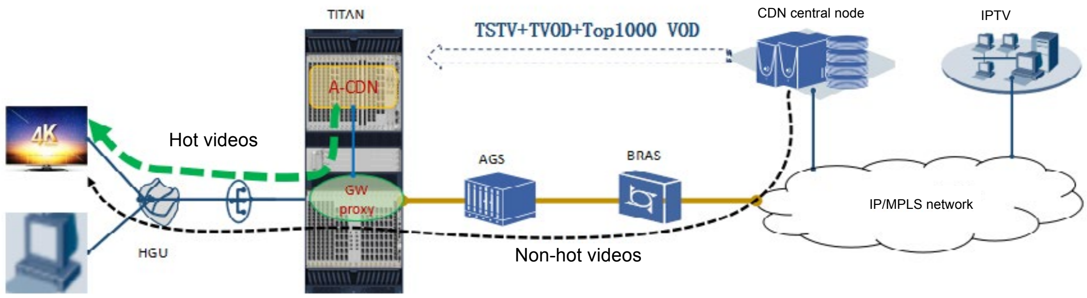

Fig. 4. TITAN's built-in A-CDN solution.

access CDN (A-CDN), is deployed through building blade servers into an OLT. A-CDN mainly stores time-shifted TV (TSTV), TV on demand (TVOD), and hotly sought-after VOD programs. TITAN offloads local traffic through its GW proxy functionality so that users can access programs stored in the nearest A-CDN. By intercepting 70% of the VOD traffic, the following objectives can be achieved:

- Improving user experience: High-bit-rate 4K/8K/VR services can be deployed close to end users to take advantage of the high bandwidth of PON. This ensures high throughput, low latency, no congestion and great service experience. It can also effectively cope with the traffic bursts caused by heavy demand for hot videos within a short period of time.
- Saving network bandwidth: By deploying services close to end users and intercepting 70% of the VOD traffic, A-CDN significantly reduces the bandwidth required by the convergence network, metro network and related network equipment and the load on the CDN central node, effectively cutting the bearing cost of the big video network.
- Simplifying engineering implementation: The TITAN with built-in blade servers supports low power consumption, high performance, on-demand deployment and strong scalability. It does not require reconstruction of the equipment room and frequent network upgrades, greatly reducing the workload of service deployment and capacity expansion.
- Efficient and smart CDN: A-CDN can use real-time information of the access network to schedule content and services in a smart, efficient way to further improve user experience and network transmission efficiency.
- Shared infrastructure: The TITAN OLT with its built-in blade servers constitutes an edge cloud computing platform and an NFVI platform, which can be shared by VNF, CDN and other edge computing services. This advances the construction of edge and service clouds at a low cost.

TITAN's Built-in OTN for Integrated Transmission and Access

TITAN can include built-in 100G OTN cards to integrate transmission and access. Managed by a unified network management system, it realizes end-to-end mapping of user traffic into OTN timeslots, simplifies service deployment and O&M, and enables end-to-end deployment of large-granularity, low-latency services while ensuring that service transmission is transparent with fixed latency and no jitters. Furthermore, in contrast to the traditional OTN equipment, the TITAN with integrated transmission and access reduces equipment room space and decreases power consumption, hence considerably cutting Capex and Opex for the operators.

Conclusion

With a deep understanding of the network trends and the aim of delivering FMC services, ZTE has launched an innovative integrated OLT architecture, and a series of solutions, including 5G fronthaul and backhaul, built-in BNG, built-in A-CDN, and transmission/access integration, to help operators prepare for the 5G era.

Multi-Service and Multi-Tenant Scenario:

A Typical Application of NFV in Access Network

By Diao Yuanjiong

Requirements for Multi-Service and Multi-Tenant Access

In the optical access network (OAN), optical distribution network (ODN) is a key resource and an important asset for operators. In addition to vigorously deploying FTTH-based home broadband services in the areas covered by existing ODNs, operators also actively develop other services and explore new business models including network leasing/sharing to boost revenue and shorten the investment return cycle.

In a multi-service scenario, the access network concurrently provides access to multiple services. In other words, multiple services share the same access network. An operator uses the same access network to operate multiple services and offer differentiated QoS guarantees. Typical fixed-line multi-service scenarios include home broadband as well as government and enterprise business. Typical 5G multi-service scenarios are enhanced mobile broadband (eMBB), massive machine-type communication (mMTC), and ultra-reliable low latency communication (uRLLC).

Multi-tenant sharing allows an access network to simultaneously provide services for multiple operators, that is, multiple operators share the same access network. The operator who owns an access network is called the infrastructure provider (InP), while the operator who leases the access network for business operation is called the virtual network operator (VNO). As agreed in the business contract, the InP logically partitions the access network and assigns the resources of a logical partition to a VNO so that the VNO can independently operate them.

Multi-service and multi-tenant access can be understood as two dimensions of access network sharing. Multi-service access is the horizontal dimension, where the access network is shared by different

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services; multi-tenant access is the vertical dimension, where the access network is shared by different operators. The two dimensions can exist concurrently. For example, a public access network is planned in the Xiong'an New Area in China's northern province of Hebei. The access network can be shared by the three major operators in the country—China Unicom, China Mobile and China Telecom. Each operator can operate multiple services such as home broadband, base station backhaul, and enterprise leased line.

In a complex access network sharing scenario where multiple services and tenants co-exist, different VNOs provide their users with services that fulfill respective service level agreements (SLAs). The access network needs to support concurrent, independent management by multiple VNOs and to provide differentiated QoS guarantees for multiple services. To implement multi-service access and multi-tenant sharing of the optical access network, an InP must consider and plan for network architecture evolution and select a proper new-generation optical access solution.

Introduction of Network Functions Virtualization

Network functions virtualization (NFV) has the ability to provide network function as a service (NFaaS). Therefore, NFV can be introduced in the access network to meet the need of network functions as different roles such as end users, VNOs and an InP in a complex multi-service multi-tenant scenario.

Currently most network devices are purpose-built in their entirety or their hardware. They come from only a few vendors, cost a lot and are difficult to scale. These problems can all be addressed by NFV. Through functional analysis, logical partitioning, network function (NF) module setting, NF module function definition, NF module interface definition and NF module development, NFV enables one or more virtual network functions (VNFs) to run on commercial off-the-shelf (COTS) hardware. Thanks to NFV, a combination of COTS hardware and VNFs can even be used to replace some types of purpose-built network devices and hardware.

NFV decouples network functions and purpose-built devices, offering operators more choices and greater flexibility in the use of network equipment. In addition to purchasing COTS hardware like blade servers and storage devices, operators can even develop VNF software to implement specific service management and control functions to provide differentiated services.

To enable application scenarios where the access network is shared by multiple services and tenants, the new-generation optical access solution needs to have the following capabilities:

- On-demand network connectivity that allows for easy control of the connections between end users and VNFs
- VNF as a service that facilitates customization by VNOs
- NFV infrastructure (NFVI) that enables VNOs to develop their own VNFs.

TITAN Enables Multi-Service and Multi-Tenant Scenario

ZTE's TITAN is a new-generation OLT that supports NFV evolution and can meet the need for multi-service and multi-tenant applications in an access network sharing scenario.

The NFV deployment strategy of the TITAN solution complies with the BBF TR-384 specification—*Cloud Central Office Reference Architectural Framework*. Some highly real-time service management and control functions, including PLOAM and DBA of GPON as well as LACP, xSTP and OAM of Ethernet, are encapsulated as physical network functions (PNFs) and kept in TITAN. The other management and control functions can be deployed according to customer requirements either in VNFs in the cloud or in PNFs in physical devices (Fig. 1).

A highlight of the TITAN solution being applied in an access network sharing scenario is the implementation of physical resource abstraction, data modeling and resource mapping on generic compute and storage resources in the cloud. This implementation is carried out by ZTE's ElasticNet unified management

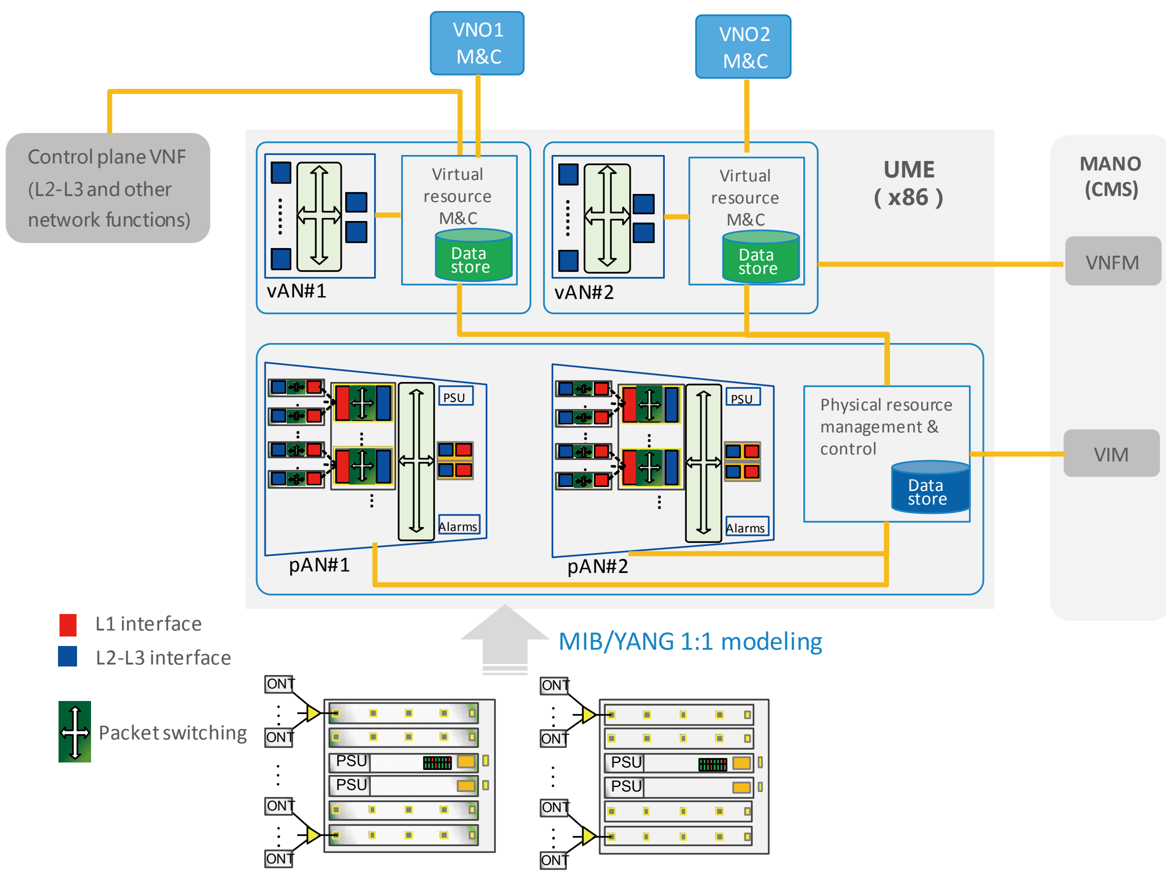

Fig. 1. Implementation of virtual access nodes (vANs) in CloudCO.

expert (UME). UME runs on the cloud and consists of two layers. The southbound or lower layer maps physical resources, while the northbound or upper layer abstracts virtual resources.

In its physical resource mapping layer, UME sets up a 1:1 physical access node (pAN) for each physical OLT. By using an independent database to store the static configuration and dynamic status information of every pAN, UME supports the offline configuration of physical access devices. Multiple physical resource management and control module instances can be created in the physical resource mapping layer of UME. Each instance can concurrently manage and control multiple and various pAN entities. For example, for different OLT models (C610, C650, C600, etc.), their software and hardware characteristics are represented in corresponding pAN data models. In addition, UME supports multiple pANs that are connected by physical links and can be simulated into one pAN to implement cluster management and control based on multiple-to-one mapping.

In its virtual resource abstraction layer, UME extracts pAN instances related to the data model of access-network-sharing services. Such instances include logical Ethernet subinterfaces, forwarding instances, traffic management (TM) characteristics (scheduling and rate limiting), performance management (PM) characteristics (statistics), and alarms. Meanwhile, UME ignores the information or characteristic irrelevant to the data model of access-network-sharing services, such as power supplies, fans and line cards. By combining resources as needed, UME creates a logical access device entity, establishes a data mapping link, and sets up a corresponding virtual access node (vAN). Resource combination can be based on a service, a VNO, or a service of a VNO. UME also uses an independent database to store every vAN data and supports the offline configuration of logical access devices. Compared with the pAN data model, the vAN data model focuses more on service description. For example, vAN in an OLT usually adopts an L2 Ethernet switching equipment model, while related characteristics of L1 interfaces (such as PON ports) are kept in pAN.

pAN is an abstraction of a physical device while vAN is an abstraction of a logical device. When UME processes the two layers of abstraction, it supports capability adaptation and coupling between pAN and vAN. The resource isolation level supported by physical devices will affect the configuration mode of vAN. For example, ZTE's OLT C300 supports isolation between forwarding instances including VLAN and VRF but not between the packet buffer and MAC address table. In a UME, C300 pAN will display this isolation capability. When UME manages multiple vANs in the same C300 pAN, it will use the isolation capability and employ techniques like address isolation/arbitration to prevent logical resource conflicts between vANs.

The TITAN-enabled NFV solution has the following characteristics:

- The virtual resource abstraction layer of UME provides stakeholders like VNOs with programming interfaces for virtual access devices.
- The physical resource mapping layer of UME offers management and control interfaces for physical access devices. The plug-ins of a third party can be used to manage access devices of other vendors.
- UME supports several mapping modes between physical and logical devices, such as one-to-multiple slicing mode (where one physical device is partitioned into multiple logical devices) and multiple-to-one expansion mode (where multiple physical devices are merged into one logical device).
- The deployment of UME is based on an NFV architecture that uses off-the-shelf compute and storage resources. UME supports virtualization technologies including virtual machines and containers. Microservices are leveraged to enable independent evolution and flexible expansion of different management and control functions as well as different instances in the UME.

ZTE's NFV solution in the access network opens up a path of evolution from a single FTTH scenario to multi-service and multi-tenant scenarios. With the solution, end users, VNOs and InPs can define their own VNFs and build their respective virtual access networks according to their different roles in the access network. The access network infrastructure will ultimately be shared by multiple services and multiple tenants. ZTE TECHNOLOGIES

Converging Access Network with OTN and BNG to Flatten the Overall Network

By Jiang Xiaolin

Jiang Xiaolin
Chief Engineer for FN Product Planning, ZTE

Network Evolution Drives the Convergence Trend

Improved access capability of OLTs creates conditions for network flattening. The trunk fiber of a PON has a range of 20 to 40 km, and the point to multipoint architecture of the PON allows the OLT to support large-capacity user access. ZTE's flagship ultra-large capacity OLT, the TITAN, can connect 32,000 users with a single frame and 64,000 users with two frames stacked, capable of replacing multiple OLTs and convergence switches in an existing access office (AO). Integrated with the OTN functionality, the TITAN can vastly cut equipment footprint, reduce device types and power consumption, thereby slashing operators' Capex and Opex. By integrating transport and access, the TITAN can also deliver the high bandwidth and low latency needed to carry 5G and big video services.

SDN/NFV technologies advance network evolution. A commonly used virtual broadband network gateway (vBNG) solution employs universal servers for control plane virtualization and specialized devices for high-performance forwarding in the forwarding plane. Since the TITAN is based on a high-end distributed router platform, it can provide the capability required by the BNG forwarding plane. While the BNG control plane is cloudified, the BNG forwarding plane can be integrated with the OLT. That eliminates the need to deploy specialized BNG equipment for a forwarding plane, which makes the network flatter and cuts network costs. The integration of the OLT with the BNG also means that the L3 functions are moved to the OLT, meeting the 5G bearing requirement of moving L3 to the edge and laying

a foundation for future movement of the CDN into the AO.

Multi-Service Bearing Drives Convergence of Access Network with OTN

The growth of new services, including 5G, big video, VR/AR and high-speed dedicated lines for governments and enterprises, spurs the demand for bandwidth. This trend compels operators to build an end-to-end OTN that covers the access layer, convergence layer and trunk lines. That is where the ZTE TITAN comes in. The TITAN supports built-in OTN uplink to simplify the network layers, as well as optical pass-through to shorten latency, thus helping operators reduce network construction and maintenance costs.

5G Scenario

5G has higher requirements for bandwidth, latency, reliability and security, which presents an enormous challenge for the bearer network. With a focus on user experience, 5G must offer data speeds of hundreds of Mbps (even of Gbps order) per user and up to tens of Gbps per base station. The expected super-high access rates requires that the bearer network to provide one or two orders of magnitude more bandwidth. 5G covers application scenarios with varying latency requirements, of which ultra-reliable low latency communication (uRLLC) requires the lowest latency. While NGMN suggests the one-way end-to-end latency for uRLLC should be less than 1 ms, 3GPP defines uRLLC air interface latency as 0.5 ms. Besides, there is latency in core network, and then the remaining latency budget for bearer network is extremely low. These requirements present huge challenges to both 5G fronthaul and middlehaul networks.

The ZTE TITAN optical access platform supports WDM-PON access at the user side, low-latency forwarding in the forwarding plane, and built-in OTN uplink at the network side, enabling the transport of high-bandwidth, low latency services, unified 5G fronthaul, middlehaul and backhaul bearing, and FMC. Connected to the transport network via the OTN interfaces on the uplink network side, the TITAN implements end-to-end mapping of user traffic into OTN timeslots, simplifies service deployment and

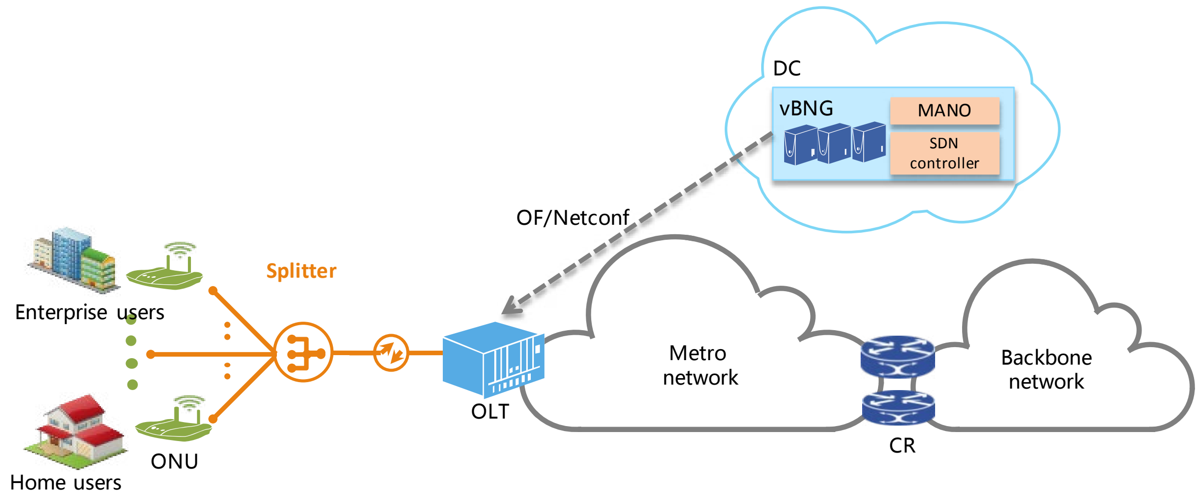

Fig. 1. Overall framework for converging the OLT with the BNG.

O&M, and enables end-to-end deployment of large-granularity, low-latency services while ensuring transparency of transmission (fixed latency and no jitters). With a dedicated logical pipe, the TITAN ensures the quality and security of 5G services and provides a low-latency solution.

Big-Video Scenario

Big video services not only require high bandwidth but also low packet loss ratios and low latency during transmission. For 4K TV, the latency and the packet loss ratio should not be higher than 20 ms and 0.0168% respectively, which can be realized by optimizing the existing networks. For 8K TV, the latency and the packet loss ratio should not be higher than 16 ms and 0.001% respectively, while the thresholds for VR are 12 ms and 0.001%, which requires adjustments to the existing network architectures and equipment. The CDN is usually deployed centrally for better management and resource utilization. The OLT directly connects to the CDN servers via built-in OTN uplink interfaces to avoid latency and packet loss caused by L2 and L3 forwarding equipment. This scheme can significantly improve user experience, especially for latency-sensitive fast channel switching services and AR/VR services, which are susceptible to latency, packet loss and bandwidth.

Virtualization and Multi-Service Bearing Drive Convergence of Access Network with BNG

Convergence of OLT with BNG Spurred by SDN & NFV

Nowadays network transformation with SDN and NFV is an industry trend. A focus for the future modernization of metro and access networks is to build an access edge that integrates multiple services. BNG virtualization is a hot topic, for which, various approaches have been proposed. Since the forwarding performance of the existing x86 servers is inadequate, separating the control and forwarding planes is a widely accepted solution for the present. This solution uses universal servers to implement virtualization in the control plane and specialized devices to implement high-performance forwarding in the forwarding plane, as shown in Fig. 1. In the figure, the control plane is represented by the vBNG, and it uses an NFV architecture for virtualization. With the decoupling of services from the hardware platform, the vBNG can utilize a universal platform to enable flexibility, convenience, and reduced TCO, and allow dynamic creation of services and opening up of capabilities. In addition, a modular design and a flexible loading mechanism make the software system of the vBNG highly adaptive.

With the cloudification of the control plane, the OLT can converge with the traditional BNG forwarding plane and avoid the deployment of dedicated BRAS hardware for a forwarding plane. This scheme gives full play to TITAN's fully distributed switching architecture to flatten the network and slash the network upgrade costs. The forwarding plane is centrally controlled through an SDN architecture. An SDN controller, which integrates management and control, and a service orchestrator are deployed to enable end-to-end automatic configuration and an intelligent and open network. The convergence of the OLT with the BNG also means that the L3 functions are moved to the OLT, allowing the bearing of 5G services and the future movement of the CDN into the AO.

L3 to the Edge to Enable 5G Bearing

Compared with 4G, the 5G network architecture will be flatter. Some old as well as new functions (such as mobile edge computing) will be deployed closer to the end users. The existing traffic pattern based on south-north convergence will undergo a major change. East-west traffic between different 5G network elements, for instances, between gNBs and between a CU/DU, will increase drastically. East-west traffic is more sensitive to latency, and should be forwarded at a location as close to the access layer as possible. That puts new demands on the east-west traffic scheduling of the backhaul or even the fronthaul and middlehaul networks, which can be met when the OLT provides flexible L3 connectivity. With L3 capabilities centrally managed and controlled via SDN, coordinated traffic across base stations can be forwarded close to the base stations to maximize synergy gain, and on-demand, real-time connections between wireless and core networks can be set up. By introducing new technologies like Segment Routing/EVPN/VXLAN, the network protocols and O&M can be simplified to better cope with future data-center-focused network architecture evolutions.

L3 to the Edge to Enable Movement of CDN into the AO

Deploying the CDN in a centralized way allows resources to be efficiently managed, maintained and utilized. However, it also has many drawbacks, including more traffic pressure on the convergence and metro networks, higher latency, and increased packet loss in the event of network congestion. These drawbacks hinder the high-quality transmission of big video services, especially latency-sensitive fast channel switching services as well as AR/VR services that can be affected by latency, packet loss, and bandwidth. If the CDN is moved to the AO, IPTV and OTT video services can be delivered from locations close to the end users to greatly improve service quality.

Conclusion

ZTE's TITAN optical access platform, based on a high-end distributed router architecture, supports large-capacity user access, convergence switch functions, built-in OTN boards, and convergence of the BNG forwarding plane with the OLT to realize network equipment integration and network flattening. With the built-in OTN boards, the TITAN can deliver the high bandwidth and low latency needed to transport 5G and big video services. With the convergence of the BNG forwarding plane with the OLT, the L3 functions can be moved to the OLT, which is also needed by 5G and big video services. ZTE TECHNOLOGIES

Discussion on Applying a Converged CDN in the Access Office

By Tian Hongliang

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Status and Challenges of CDN

Although the internet is ubiquitous now in people's life and work after decades of high-speed development, content access has always been one of its primary functions. Increases in content types, video bitrates and terminal types all lead to rises in content traffic. Consequently, the bottleneck of core networks becomes more severe and degrades user experience. This gives rise to a content delivery network (CDN) that can improve quality of experience (QoE), reduce backbone network traffic and properly distribute content traffic. By directing user requests to suitable service nodes through content delivery and service scheduling, CDN provides distributed content service.

Depending on the content they deliver, CDNs fall into two categories: specialized CDNs and converged CDNs. A specialized CDN delivers a specific type of content. For example, an IPTV CDN specifically carries IPTV video content. A converged CDN can deliver multiple types of content and support many different terminal types. Operators mostly choose the converged CDN in their construction.

Currently operators run a converged CDN at the provincial level. The CDN employs a two-level architecture that comprises a provincial-level central node and city-level edge nodes (Fig. 1). In few large cities that include high-traffic districts, the edge nodes have moved closer to the broadband network gateway/service router (BNG/SR) level, forming a three-level CDN architecture.

The above architecture has both advantages and disadvantages. It can significantly cut backbone network traffic and long-distance (from prefecture-level city to provincial capital) transmission cost. Nodes at both levels can be massively deployed

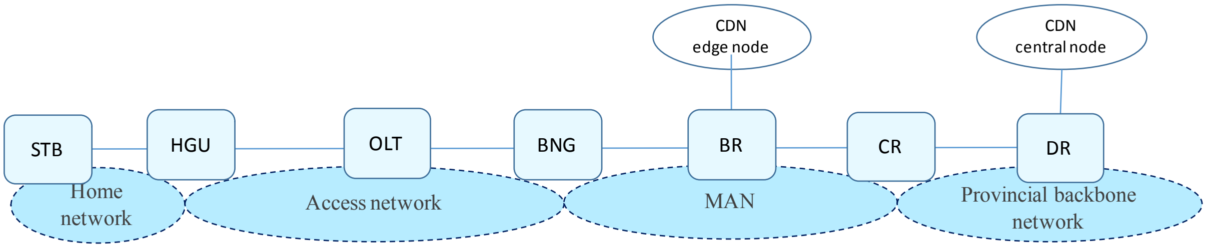

Fig. 1. Two-level CDN architecture: a provincial central node + city edge nodes.

with a mature construction solution. The nodes can be co-located with edge and provincial data centers (DCs) to share a computing and storage infrastructure. However, the architecture also has obvious disadvantages. First, edge nodes are placed far from end users. As a result, many hops are needed in a service path, QoE is difficult to assure, and fault location and removal is complex. Second, the network segments from OLT to BNG and from BNG to boundary router (BR) tend to become bottlenecks as service traffic surges. Finally, this architecture does not leverage the low-cost and abundant-bandwidth advantages of an optical access network. The disadvantages will become ever more noticeable as 4K/8K/AR/VR video content become ubiquitous.

With the emergence of edge computing and the introduction of SDN and NFV, it has become a trend to introduce NFV infrastructure (NFVI) in the access office. If the NFVI in the access office can be fully utilized so that converged CDN services can be deployed near end users and a three-level CDN architecture can be built, the disadvantages mentioned above in the two-level CDN architecture can be effectively avoided. This article is intended to discuss this approach. By introducing a new converged CDN solution based on ZTE's TITAN platform, the article gives good thought and suggestions for operators to deploy converged CDNs in their access offices.

Introducing A-CDN to Build a Three-Level Converged CDN Architecture

An access CDN node (A-CDN) can be introduced

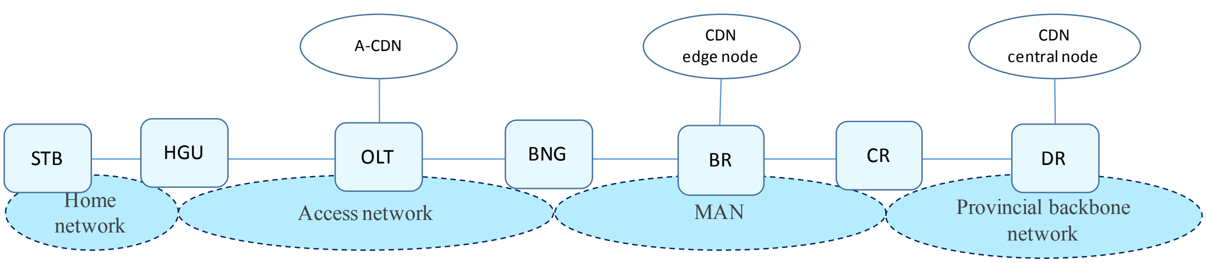

Fig. 2. Introducing A-CDN to build a three-level converged CDN architecture.

in the access office to form a three-level converged CDN architecture together with existing edge nodes and a central node (Fig. 2).

An optical access network based on the PON technology provides high access bandwidth capable of supporting heavy-traffic services including 4K/8K TV and AR/VR applications. As shown in Table 1, in the FTTH mode with a split ratio of 1:64 and a concurrency rate of 40%, GPON can support 4K TV while 10G PON support 8K TV and AR/VR commercial deployment.

Nevertheless, a bottleneck exists in the uplink bandwidth from OLT to BNG. Fiber resources between OLT and BNG are limited. An OLT has no more than four pairs of uplink fibers and each pair usually offers 10GE bandwidth, meaning that an OLT can provide only 40GE uplink bandwidth. An OLT carries 5,000 to 8,000 broadband users and busy-hour traffic per household is around 3 Mbps, which translates into a total traffic of 15–20 Gbps. Assuming that the utilization of uplink bandwidth is 70%, an OLT can carry 28 Gbps traffic in total, which means a bottleneck in the uplink bandwidth is imminent.

This bottleneck of OLT can be addressed in two ways: by increasing uplink bandwidth or moving the CDN closer to end users. The uplink bandwidth of OLT can be increased by either upgrading the uplink port or deploying OTN to the access office. Upgrading the uplink port from 10GE to 100GE requires the support of both OLT and BNG, which results in high costs and a long period of time. The upstream equipment also needs to be upgraded. Deploying OTN to the access office involves even more engineering work and higher costs. However, moving CDN closer to end users can quickly remove the bottleneck in a flexible and cost-effective manner.

The development of IT technology follows Moore's Law, which means that IT equipment cost decreases far faster than network equipment cost. As CPU capability increases dramatically and its memory and hardware performance develop rapidly, a common server can support a CDN processing capacity of dozens of gigabits per second. Consequently, it is economically feasible to get more network bandwidth at the cost of computing and storage. Meanwhile, the FTTx construction and the increasing port density of access equipment are releasing the frame and rack space in an access office. By embedding blade servers into access equipment, A-CDN can be built quickly and flexibly as desired without the need to reconstruct the access office.

An in-built A-CON is achieved by embedding CDN functionalities in OLT. Because a large-scale content storage can not be configured, the content scheduling algorithm of CDN needs to be optimized. In other words, A-CDN needs to store the hottest programs to improve the content hit ratio, and users can access services from the nearest A-CDN.

ZTE's A-CDN Solution

ZTE has developed blade servers that are embedded in its TITAN new-generation OLT platform to provide an A-CDN solution.

In hardware design, the blade servers employ a powerful SoC-based CPU, NVMe SSD drives, and

Table 1. Service bandwidth requirements in the FTTH mode (1:64 split ratio and 40% concurrency rate) .

PON technologies	Average home bandwidth	Configured bandwith (2.5× overprovisioning)	4K stream & bandwidth (30 M /40 M)	8K stream & bandwidth (120 M /150 M)	AR/VR stream & bandwidth (60 M /200 M)	Commercial use
GPON	40 Mbps	100 Mbps	2 channels	-	-	Already commercialized
10G PON	160 Mbps	400 Mbps	2 channels	2 channels	1 channel	By 2020

10G network ports. Each blade server occupies two service slots and can be inserted in any slot in the TITAN OLT. In software design, the embedded blade servers run on ZTE's proprietary CDN software. Evaluation and verification show that the blade servers can deliver a converged CDN service capacity of 20 Gbps and provide 70% of the CDN service for 20,000 users in the same access office. This vastly reduces OLT's uplink bandwidth of the converged and metro networks and delays the need for chain network upgrade. To suit the A-CDN scenario, ZTE's CDN software system has been optimized in storage and content.

- A-CDN storage optimization: Store three types of most broadcast content including three-hour live-channel time-shifted TV programs, TVOD programs in a week, and 5,000 movies that are currently broadcast most. A-CDN has a total storage capacity of less than 16 Tbps but can cover 70% of the VOD service.
- A-CDN content update optimization: Use big data to analyze and optimize regional hot content and the cooling model of hot content so that the cached content can be promptly and accurately updated and scheduled.

TITAN has embedded the traffic offload functionality to avoid adversely affecting VLAN, IP planning and BNG user management. Through listening and learning, TITAN offloads according to destination IP addresses the traffic generated to access A-CDN. It implements PPPoE/IPoE gateway functionality in advance without affecting the other traffic. This mechanism is fully transparent to BNG/SR, STB and A-CDN, which facilitates engineering and deployment.

Conclusion

As video traffic grows exponentially, it is increasingly important for CDN to ensure user experience. The A-CDN architecture and key technologies are used to embed CDN functionalities in OLT. The low-cost flexible A-CDN solution can help operators rapidly upgrade capacity and deploy their big video services to meet future traffic challenges.

Technical Analysis of CloudCO Architecture

By Xie Yu

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Background

Telecom operators long for a network that is adaptive, flexible, scalable and dynamic. They need the network's ability to facilitate the development and launch of new services to help them reduce Capex and Opex. Cloud-based telecom network, a product of the convergence of IT and CT sectors, is expected to fulfill the operators' objective and has attracted widespread industry attention.

The maturing of software-defined networking (SDN) and network functions virtualization (NFV) technologies in recent years lays the foundation for designing and deploying networks with a cloud architecture. As the main standards body for broadband access, the Broadband Forum (BBF) released the *TR-384 Cloud Central Office Reference Architectural Framework* in January 2018, which provided a standard for operators to re-architect their broadband networks.

The cloud central office (CloudCO) architecture aims to build a general-purpose cloud broadband platform that has open interfaces and serves both wireline and wireless networks. This can be achieved by leveraging generic data center (DC) style resources including computing, storage and switching equipment to re-architect the access and metropolitan area networks. To allow for the reuse, convergence and evolution of existing networks, the central office (CO) should be the best place where the cloud platform is deployed.

The CloudCO architectural framework fully considers the smooth evolution strategy as well as the compatibility with existing networks to enable co-existence of traditional networks and CloudCO networks. Therefore, the CloudCO architecture is capable of providing operators with a feasible cloud network evolution solution.

Technical Analysis

The CloudCO reference architecture specified in BBF TR-384 is shown in Fig. 1. A CloudCO is deployed as a domain and can be viewed as a hybrid architecture combining physical infrastructure and network functions virtualization infrastructure (NFVI). In other words, virtual network functions (VNFs) residing in NFVI connect the access and network sides through physical network functions (PNFs) to provide external services. End-to-end services are scheduled and orchestrated by a CloudCO domain orchestrator or even by a service chain that may involve multiple CloudCO domains.

The CloudCO architecture has the following benefits:

- Granular control of system-level network and service design by decoupling the traditional network equipment into independent standard

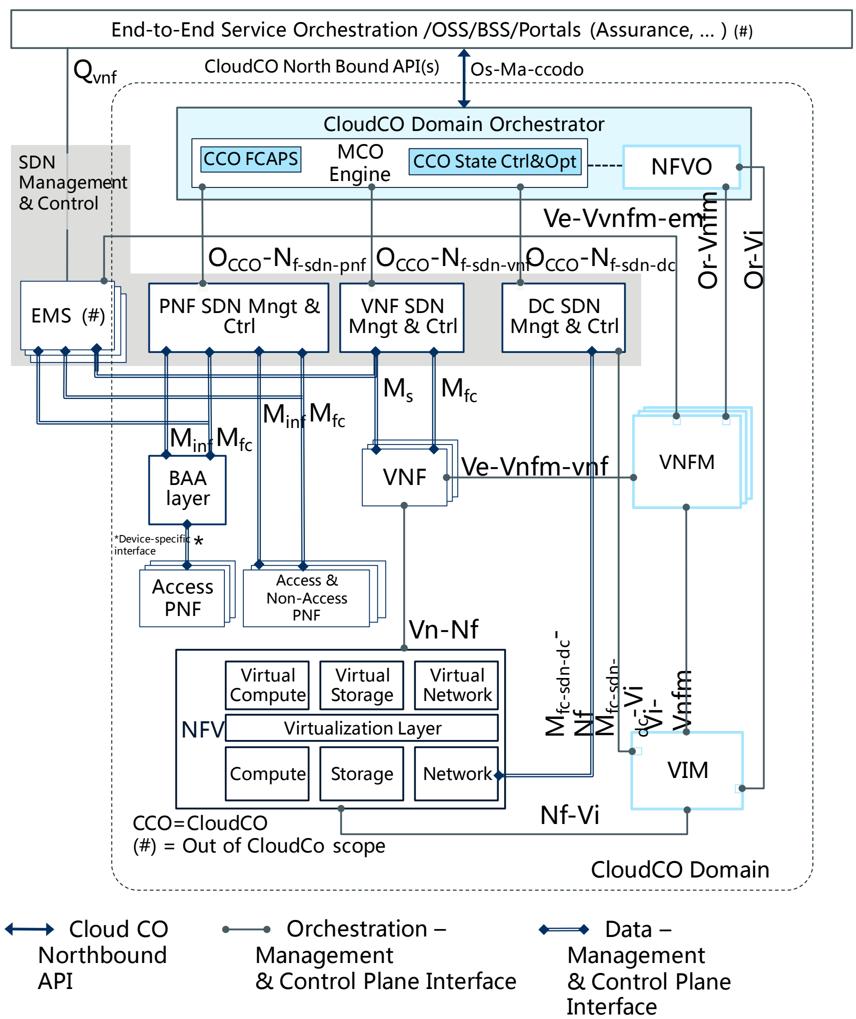


Fig. 1. CloudCO reference architecture based on TR-384.

network functions
- Better flexibility and scalability by deploying virtual network functions
- Automatic and fast service deployment and go-live by orchestrating services.

The main functional modules of the CloudCO reference architecture are the CloudCO domain orchestrator, NVF orchestrator, PNF SDN manager & controller, VNF SDN manager & controller, DC SDN manager & controller, and broadband access abstraction (BAA) layer.

The CloudCO domain orchestrator is the core of the entire CloudCO domain. Externally, it provides services through northbound application programming interfaces (NB APIs). Internally, it centrally schedules the available resources in the CloudCO domain to satisfy service requests. For example, it selects and configures the needed PNF and VNF instances, or establishes the service chain forwarding path between the PNF and VNF instances. On top of individual CloudCO domain orchestrators usually exists an end-to-end (E2E) service orchestrator that provides operators with a view of the whole service chain and performs higher-level E2E service orchestration such as CloudCO domain selection, inter-CloudCO-domain connection and intra-CloudCO-domain service orchestration.

The main components of the CloudCO domain orchestrator are the NFV orchestrator (NFVO) and management control orchestration (MCO) engine. The NFVO is responsible for NFVI resource orchestration across virtualized infrastructure managers (VIMs) and for lifecycle management of network functions (NFs). The MCO engine oversees a continuum of tasks related to the CloudCO domain: resource/status orchestration, traffic flow management and control, and CloudCO state transition and supervision. The engine performs interaction between service level systems (such as E2E service orchestrator and OSS/BSS) and the CloudCO domain. It exposes upwards the topology and status of a hybrid network comprising PNFs and instantiated VNFs in the CloudCO domain via the NB API, and runs downwards the tasks delivered by the NB API through the southbound interfaces (SBIs) oriented to the PNF managers & controllers, VNF manager & controllers and DC SDN managers & controllers.

The PNF SDN manager & controller, VNF SDN manager & controller, and DC SDN manager & controller govern their respective resources in the CloudCO domain. The PNF SDN manager & controller is responsible for PNF devices, the VNF SDN manager & controller for VNFM-based VNF instances, and the DC SDN manager & controller for NFVI resources.

The BAA layer is a highlight of the CloudCO architecture. The layer exposes, via a standard NB API, a simplified functional view of access devices which is independent of vendors or even independent of specific access technology. The BAA layer helps those access PNFs not complying with the CloudCO interface standard such as the PNFs provided by traditional devices to be managed by the PNF SDN manager & controller, so that the evolution to CloudCO can be completed. The functional block diagram of the BAA layer defined in TR-384 is shown in Fig. 2.

The southbound layer of the BAA layer contains device driver plugins that support communication with the access device of multiple vendors and types in the network. In the northbound direction, the device drivers only have to comply with the southbound abstraction interface (SAI) which is the standards-based interface between the BAA core and the access devices. In the southbound direction, the device drivers can use private interfaces to interwork with specific devices. The northbound layer of the BAA layer communicates with one or several control and management elements which may include access network controllers, SDN controllers and orchestrators. The elements can communicate with the BAA core functions via different protocols.

The BAA layer can be implemented in several ways. It can reside in NFVI of the CloudCO domain as a software function instance, or in a physical access device as a means to upgrade the device. Wherever the BAA layer resides, it must meet the

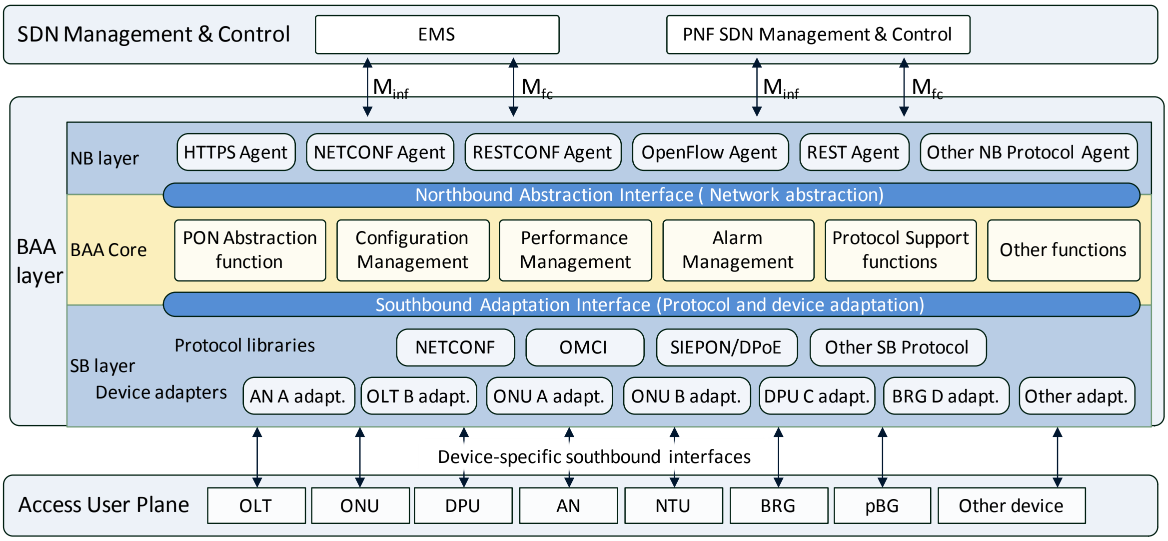


Fig. 2. Functional block diagram of the BAA layer.

related CloudCO architecture requirements, such as those concerning go-live of virtual functions and the lifecycle orchestration.

Development Trends

Since the TR-384 CloudCO architectural framework was released in January 2018, BBF's CloudCO project team has forged ahead with the subsequent standardization work. The following CloudCO standards have been initiated and are being drafted by BBF:

- CloudCO migration and co-existence (WT-408); migration to SDN-enabled management and control (WT-413)
- Definition of interfaces between CloudCO functional modules (WT-411)
- Test cases for CloudCO applications (WT-412)
- Use cases and scenarios for CloudCO (WT-416)

The following CloudCO application notes are being discussed by BBF:

- Bootstrapping an NFVI to a cloud central office
- Establishing high speed internet access (HSIA) service
- Network enhanced residential gateway (NERG) service initialization with flat logical subscriber link (LSL) connectivity
- Network enhanced residential gateway (NERG) service initialization with overlay logical subscriber link (LSL) connectivity
- Activation and initial provisioning of access devices
- Virtual access node (vAN)-based FANS service
- SDN-based FANS service

In addition, BBF has launched the Open Broadband-Broadband Access Abstraction (OB-BAA) initiative, an open source project that BBF hopes can provide a reference implementation of the BAA layer. The initiative is intended to incorporate different access network (AN) devices, including traditional AN equipment, into a single network management and control domain and expose them to the SDN manager & controller and EMS.

As an important member of BBF, ZTE has long been part of its discussions, proposals and reviews on broadband access standards. The CloudCO project, currently a priority for BBF, has also gained full support and participation of ZTE.

Single-Wavelength 50G PON

Implementation and Its Application Prospects

By Huang Xingang

Huang Xingang
Pre-research Project Manager, ZTE

Trends of Optical Access Network Technologies

Optical access network technologies have experienced rapid advance in recent years amid a sustained rise in user demand for bandwidth. As EPON and GPON increasingly fall short of operational needs, operators have begun mass deployment of 10G PON. The IEEE is formulating the NG-EPON standard, while the ITU-T has started the standardization work of 50G PON.

When it comes to the method for improving system bandwidth beyond 10G PON, the industry has not yet reached a consensus on whether to increase single wavelength rates or to multiplex multiple wavelengths. Discussions are being focused on three solutions: single-wavelength 25G PON, single-wavelength 50G PON and multi-wavelength 100G PON. Single-wavelength 25G PON is easy to implement but produces only modest rate improvement over 10G PON. Single-wavelength 50G PON yields significant rate improvement but presents power budget challenges for the PON system. These challenges may be overcome by using optical amplification technology. 100G PON provides huge rate improvement but imposes high requirements for photoelectric components. Normally 100G transmission is achieved by multiplexing multiple wavelengths (four 25G wavelengths or two 50G wavelengths).

Single-Wavelength 50G PON Implementation

Single-wavelength 50G can be implemented through non-return-to-zero (NRZ) or higher-order modulation. NRZ modulation requires 50G optical components, but their development is still at the sample stage. Higher-order modulation comes in various schemes such as 4-level pulse-amplitude modulation (PAM-4), duobinary, and discrete multitone (DMT). PAM-4 and duobinary need 25G optical components. DMT is an orthogonal frequency division multiplexing (OFDM) technology that requires fast Fourier transformation (FFT). The component bandwidth of DMT is related to the modulation order of each subcarrier. The higher the modulation order, the smaller the component bandwidth and the worse the sensitivity. The modulation schemes ranked in descending order by sensitivity are DMT, PAM-4 and NRZ.

For single-wavelength 50G transmission in the optical access network, PAM-4 and duobinary are the main modulation schemes because they can reuse the already mature 25G components used in the data center industry chain.

Single-Wavelength 50G PON Based on PAM-4 Modulation

While a symbol of an NRZ signal only has two levels carrying 1-bit data, a symbol of a PAM-4 signal has four levels that carry 2-bit data. The component bandwidth of PAM-4 is only half of that of NRZ, which allows PAM-4 to use 25G components for 50G signal transmission. Although PAM-4 can reduce component bandwidth requirements, its signal reception sensitivity is 5 to 6 dB worse than NRZ.

PAM-4 signal transmission and reception usually involves digital signal processor (DSP). The data signals to be transmitted first enter the DSP for PAM-4 mapping and pre-equalization, then are converted into analog signals by a digital-to-analog converter (DAC), and finally is sent to an optical link via the optical transmitter. At the receiver side, the signals undergo a photoelectric conversion by an optical receiver, then are convert into digital signals by an analog-to-digital converter (ADC), and are finally sent to the DSP. At the DSP, digital signals goes through clock recovery and equalization. The original data signals are restored after symbol decision and demapping. To reduce physical layer requirements and improve transmission performance, forward error correction (FEC) is generally performed at the transmitting and receiving ends.

Fig. 1 shows the BER curve of 50G PAM-4 signals. The performance of the transmitter (25G EML) and receivers (APD and SOA+PIN) is tested. When the RS (255, 239) FEC algorithm is used, the receiving sensitivities are –20 dBm and –22 dBm respectively. For a 29 dB power budget to be achieved for the PON system after considering the optical link transmission penalty, the transmitter's optical power needs to be at least 10 dBm and 8 dBm, and the transmitter needs to integrate an SOA. If the low-density parity-check (LDPC) error correcting code is used to relax the BER of the receiver to 10E-2, the receiving sensitivities are –22.5 dBm and –26 dBm respectively, and the transmitter's optical power needs to be greater than 6.5 dBm and 3 dBm. The transmitter needs to integrate an SOA to reach 6.5 dBm, but 3 dBm can be achieved by an ordinary laser.

Single-Wavelength 50G PON Based on Duobinary Modulation

Although the duobinary code has the same symbol rate as that of NRZ code, its spectrum bandwidth is only half of the NRZ code. With duobinary modulation, data can be transmitted and received in several ways. Transmission schemes include delay addition and low-pass filtering, while reception schemes include three-level decision as well as DSP equalization and recovery. The delay addition scheme is implemented by a finite impact response (FIR) filter. After the data is delayed by one bit and the next bit is added,

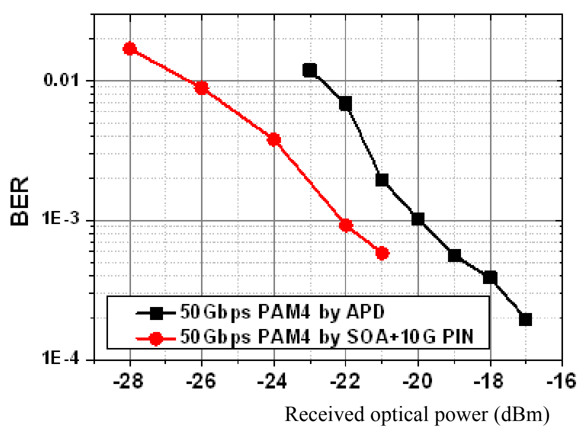


Fig. 1. BER of 50G PAM-4 signals.

the output is a duobinary code. The low-pass filter features delay addition, so an NRZ signal becomes a duobinary signal after going through a low-pass filter with an appropriate bandwidth. At the receiving end, the original signal can be recovered in two ways. One is to first employ three-level decision to recover the transmitted duobinary code sequence. After the code sequence undergoes duobinary decoding, the original data is restored. The other is to treat the received duobinary data as bandwidth-restricted NRZ data and use DSP equalization to eliminate inter-symbol crosstalk to recover the original data.

Fig. 2 shows the BER curve of 50G duobinary signals. The data is recovered using DSP equalization, and the bit error performances with or without maximum likelihood sequence detection (MLSD) decision are compared. The performance of the transmitter (25G EML) and receivers (APD and SOA+PIN) is tested. When the RS (255, 239) FEC algorithm and MLSD decision are used, the receiving sensitivities are –23 dBm and –25 dBm respectively, that is, if an APD receiver is used, the transmitter must reach at least 6 dBm to support the 29 dB power budget. In this case, the transmitter needs to integrate an SOA. If a SOA+PIN receiver is used, an ordinary transmitter will meet the power budget requirement. If the LDPC FEC algorithm is used, the receiving sensitivities are increased to -24.5 dBm and -28 dBm respectively. In this case, the transmitter does not need to integrate an SOA.

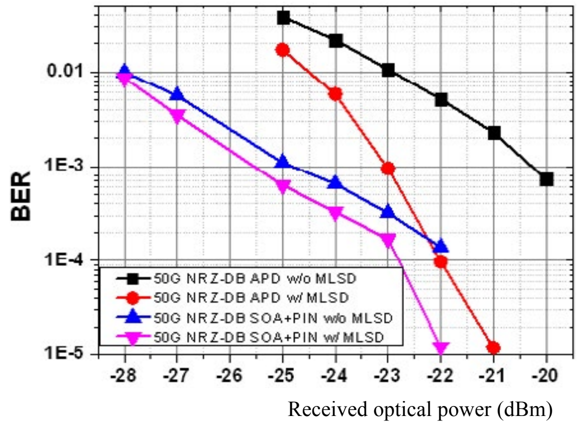


Fig. 2. BER of 50G duobinary signals.

Direction for Single-Wavelength 50G PON Development

The lasers, receivers, modem chips, serializer/deserializer (SerDes) devices needed for 50G PON transmission can be fully or partially reused from the data center industry chain. This is beneficial to promoting the maturity of 50G PON. However, the issues unique to the PON system, including upstream burst transmission, large dynamic range and high power budget, have yet to be resolved.

Upstream burst transmission is an issue to be addressed whether 50G PON employs PAM-4 or duobinary modulation scheme. The burst laser driver for the ONU upstream transmitter and the 25G burst linear transimpedance amplifier (TIA) for the OLT upstream receiver are still technical issues that need key breakthroughs in the industry chain. The existing 25G lasers and receivers can hardly support the PON system with a power budget of 29 dB, so it is necessary to develop higher-power lasers and lower-sensitivity receivers. When the rate rises to 50 Gbps, the receiver's sensitivity gets worse. As its overload power remains unchanged, the receiver's dynamic range decreases. The small dynamic range is also a problem that must be solved before 50G PON is commercialized.

Compared with the data center, the optical access network provides a longer transmission distance and requires a higher power budget. Compared with the optical transport network, the optical access network has a shorter transmission distance but needs a higher power budget because the optical distribution network (ODN) uses optical splitters. The access network is cost-sensitive because it has an enormous number of end users. To promote the development of the 50G PON industry, a balance between optical and electronic components must be achieved to produce a cost-effective solution. The data center uses PAM-4 higher-order modulation to implement high-speed signal transmission. There are numerous technologies involving designing and testing of PAM-4 modem chips and optical transceivers. The PAM-4 industry chain has already matured. Therefore, 50G PON is more likely to adopt the PAM-4 modulation scheme. The solution to burst transmission, a large dynamic range and a high power budget will be the key direction for 50G PON research in the future. ZTE TECHNOLOGIES

MPT JO: Reviving the Broadband Market in Myanmar

By Li Taozhu

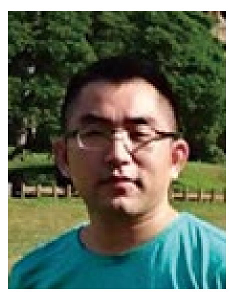
Myanmar's Budding Telecom Market

Myanmar is a populous country in the Association of Southeast Asian Nations (ASEAN) whose population stood at around 57 million by the end of 2017. In 2013, Myanmar promulgated its new Telecommunications Law that outlined a reform plan for its telecom sector by introducing private enterprises to increase competition. Soon afterwards, two foreign operators—Ooredoo and Telenor—pledged to invest billions of dollars to develop the country's telecom market. The two operators plus the state-owned MPT JO and the newly-established joint venture Mytel form the four-party competition pattern in Myanmar where all the four telecom players can operate both wireless and wireline broadband services.

After four to five years of development, Myanmar has boasted 54 million mobile users, with its wireless penetration surging to 95% and its mobile communications industry galloping ahead.

The Coming Explosive Fixed Broadband Market

As in neighboring countries, operators in Myanmar also set their first sights on wireless network construction. The total number of 2G, 3G and 4G wireless sites in Myanmar increased over 10-fold, reaching more than 20,000 at the end of 2017. Mobile phones became a necessity of the Myanmarese daily life, and Facebook and YouTube were favorite applications for the young people. However, faced with the challenges of a bottleneck for wireless user growth, a very low penetration rate of fixed broadband, and the data usage habit being acquired by users, operators in



Li Taozhu
FN Product Solution Manager, ZTE

Myanmar began to develop their new killer services one after another. They speeded up the deployment of fixed broadband (FBB) services in 2017, with the hope to offer fixed-mobile convergence (FMC) packages to enhance their brand attractiveness.

MPT JO is the largest telecom operator in Myanmar and also the only operator owning both copper and fiber resources. In 2017, MPT JO updated its FBB service packages to provide government, enterprise and home users with high-speed broadband access at rates from 1 Mbps to 100 Mbps. The services covered four tourist areas and over 70% of the population of Myanmar, making MPT JO the operator with the widest wireline coverage in the country.

The two foreign-owned operators, Ooredoo and Telenor, also entered the fray. Employing existing fiber resources on their wireless bearer networks, the two operators launched fixed broadband services in 2017. Telenor specially rolled out its broadband packages with no annual fees or subscription fees as well as its innovative service to ensure installation within seven days in core areas, attracting many new fixed broadband users. Mytel, a late joint-venture entrant to the Myanmar market, also made aggressive plans. Learning from the mature "GPON+IPTV" model operated by its investor Viettel in Vietnam, Mytel developed a strategy for 2018 that could cover the country's key townships by promoting both wireline and wireless deployments.

The First to Deploy MSAN

MPT was originally a state-owned operator governed by the Ministry of Communications and Information Technology (MCIT) of Myanmar. In 2014, MPT introduced Japan's KDDI Sumitomo Global Myanmar (KSGM) as a strategic partner to compete with Ooredoo and Telenor. KSGM promised to invest two billion dollars within 15 years starting from July 2014 to strengthen MPT's network operations.

Between 2014 and 2017, MPT JO carried out a massive network reconstruction involving multiple phases of capacity expansion for its 3G and 4G wireless networks, which helped it secure the position as the largest operator in Myanmar.

MPT JO also has nearly 600,000 fixed-line users, accounting over 90% of all wireline subscribers in the country. To meet the growing need for broadband access, MPT JO initiated the first phase of the PSTN project in 2014 to cover 160,000 users. Its objective was to upgrade the fixed networks in big cities such as Yangon and Mandalay. The existing copper resources in the user section were reused, and the convergent access sites were replaced by multi-service access nodes (MASN) that could support integration of copper and fiber. MASN would serve as a platform to develop future DSL and FTTx services. Considering the high cost of fiber deployment, MPT JO planned to adopt differentiated pricing models for different user groups. At the current stage, DSL services are targeted to existing low-bandwidth home users (less than 10M), while FTTx services are designed for customers in hotels, business districts and new skyscrapers.

Partnering with ZTE for Network Reconstruction and User Migration

In 2015, MPT JO started its PSTN reconstruction project and finally chose MASN as the new access network platform. The platform supports simultaneous configuration of POTS, DSL, P2P and GPON to meet different user requirements. Moreover, for some high-value users in cities, copper lines can be deployed within one kilometer from users so that VDSL2 can be used to improve user broadband experience.

MPT JO's reconstruction project was implemented in four phases, covering nearly 600,000 users and involving complex outside plant upgrade and fixed-line voice migration. Because routes varied greatly from area to area, upgrading the access network platform from PSTN to MSAN involved much work for each site, including a detailed survey (space, power supply, copper quality, uplink interfaces, and MDF/DC capacity), route optimization, and adding/adjusting DC locations. This posed high requirements for project execution and management. Accurate migration of voice users in batches also caused great difficulties. As MPT JO had operated voice service for many years, voice cables in the equipment room were multifarious and disordered. These cables had to be first sorted one by one, and then routes were adjusted that might involve hard engineering work such as land acquisition, pole erection, trenching, and cable burial. The five-month rainy season in Myanmar would also be a hindrance to such work.

After a rigorous selection process, MPT JO decided to award the PSTN project for Myanmar's northern part to ZTE as a turnkey package. Prior to that, ZTE had just helped MPT JO complete a turnkey FTTH deployment in the three renowned tourist areas of Inle Lake, Ngapali Beach and Ngwe Saung. MPT JO became the first operator to offer fixed broadband access in the three areas. More than 90% of hotels in the areas subscribed to MPT JO's fixed broadband services and their investments would be recouped in two years.

MPT JO selected ZTE for the PSTN project not only because ZTE is a global leader in the fixed broadband sector, but also for the long-term trust established between the two parties after many cooperative projects. ZTE entered the Myanmar market in 1999 and has operated there for almost 20 years. Apart from seven representative offices with a total staff of over 600, ZTE also locally set up a customer service center, a training center, logistics warehouses, and a spare parts base.

For the PSTN project, ZTE and MPT JO made a detailed plan for phased deployment, discussed contingency measures, and confirmed high level design and low level design (HLD/LLD) schemes for every site to reduce possible user complaints during the project process.

To deal with the huge workload of voice migration, ZTE developed an automatic sorting tool and a portable copper quality inspection device, which greatly improved migration efficiency and reduced the risks. With the joint effort of ZTE and MPT JO, the engineering efficiency was significantly improved. The Phase I project was completed nearly half a month ahead of schedule.

Enormous Potentials in the Fixed Broadband Market

While upgrading its networks, MPT JO also pays close attention to industry dynamics and competition. Feasible plans are made for GPON/XG-PON evolution, intelligent network management, and IPTV content collaboration, with an eye to advancing both copper and fiber technologies. Although many industry players have noticed its opportunities, Myanmar's fixed broadband market is still just beginning and there are many areas for improvement:

- Deepening the convergence of "fixed and mobile packages". To make the most of its strengths and boost user attractiveness, a mature mobile operator has to plan and prepare for fixed-mobile convergence (FMC) in advance, whether the convergence is at the user or network level.
- Fostering the user habit of consuming unlimited data. The biggest advantage of fixed broadband lies in its ability to offer high-bandwidth unlimited-data packages. Because there is still a shortage of bandwidth-intensive videos and applications in Myanmar, it will take time for users to create their habits around data consumption.
- Controlling cost through optimal operations. Generally, wireline broadband projects have a longer implementation cycle and involve considerable labor and maintenance costs. During network construction, operators need to consider how to reduce manual operations and fiber deployment costs that include the right of way acquisition.

Telecom has brought enormous changes to the life of Myanmar people. As Myanmar strengthens exchanges with neighboring countries and the Western world, it is embracing outside investments into its industries to jump-start economic growth. Myanmar's fixed broadband market led by MPT JO will also enter a new era.


Leading 5G
Innovations