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ZTE TECHNOLOGIES

VIP Voices

Telecom Egypt's Digital Transformation Journey

Expert Views

Evolution of Optical Access Network in 5G Era

Special Topic: **Big Broadband**

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Cover Figure | Adel Hamed, CEO of Telecom Egypt

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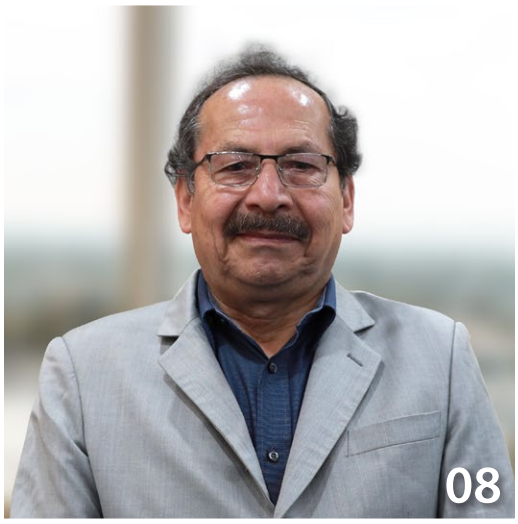


Success Story

ZTE Posts a Net Profit of RMB 1.47 Billion in H1 2019

27 August 2019, Shenzhen, China — ZTE released the interim report 2019 and the preliminary results announcement for the nine months ended 30 September 2019.

According to the report, for the six months ended 30 June 2019, ZTE reported operating revenue of RMB 44.61 billion, representing an increase of 13.1% compared with the same period last year, and net profit attributable to holders of ordinary shares of the listed company amounted to RMB 1.47 billion, representing an increase of 118.8%, compared with the same period last year. Basic earnings per share was RMB 0.35. It was estimated that net profit attributable to holders of ordinary shares of the listed company will be from RMB 3.8 billion to RMB 4.6 billion for the nine months ended 30 September 2019.

The research and development costs for the six months ended 30 June 2019 amounted to RMB 6.47 billion, accounting for 14.5% of the operating revenue, with the percentage being increased by 1.7 percentage points, compared to 12.8% for the same period last year.

Committed to building its core competitiveness in independent innovation in the 5G era, ZTE has been focusing on basic operating systems, distributed databases, core chipsets and other fields. The new-generation 5G wireless system chipsets and transport switching network chipsets have entered the stage of product introduction. The company has completed the design and mass production of the 7 nm chipsets, and embarked on the R&D of the 5 nm chipsets. Meanwhile, ZTE will collaborate closely with partners on the R&D of new technologies to accelerate the chipset R&D progress in the fields of leading process techniques, advanced packaging, core IP, and new material applications.

In the first half of 2019, ZTE has formed over 30 5G serialized solutions and implemented more than 50 demonstration projects in nearly 20 industries, including industrial internet, big video, internet of vehicles, media, energy, public safety, health care, education, environmental protection and transportation. In strategic cooperation with more than 300 industry customers, ZTE has jointly deployed service applications with them and collaborated with over 200 industry-leading product providers to launch 5G-based solutions oriented to different industries.

ZTE Teams with Smartfren to Further Indonesia's 5G Capabilities

23 August 2019, Jakarta, Indonesia — ZTE announced that it has partnered with Smartfren to support Ministry of Communication and Informatics of Indonesia to demonstrate 5G applications in the manufacturing industry, in a bid to improve efficiency, workplace safety, as well as product accuracy and quality. For this demonstration, ZTE and Smartfren deployed 5G network in a logistics warehouse, and connected the 360-degree camera and the VR headset through the 5G network, transmitting images to the monitoring room in real time. This demonstration adopts spectrum of 28 GHz at 5G medium-high-frequency mmWave, and the maximum throughput using two carriers reaches 8.7 Gbps.

"This demonstration case can be well applied for factory scenarios. Specifically, in case of a problem in the logistical and shipping path, a monitoring engineer can launch a drone to troubleshoot the problem at a short distance so that the worker does not need to trouble-shoot in a dangerous work area in person, thereby minimizing work accidents," said Merza Fachys, President Director of Smartfren.

Drei, ZTE and the Federal State of Carinthia Start 5G Operations in Digital Showcase Region "Wörthersee"

14 August 2019, Shenzhen, China — ZTE, Drei and the Federal State of Carinthia, have announced that the 5G applications have been launched in Carinthia, Austria, bringing 5G technology to life. Showcasing the new opportunities for digitalisation, tourism and the environment, real 5G applications in the 5G network and 5G smartphones will provide transfer speeds of up to one Gigabit per second.

In 2016 ZTE and the Federal State of Carinthia entered into a digitalization partnership with the aim of making Carinthia the digital flagship region of Europe. Throughout the course of its partnership and in cooperation with the Smart Urban Region Austria Alps Adriatic (SURAAA), a number of 5G developments have been made. This includes the installation of the first intelligent lighting masts in Austria, autonomous driving systems, a smart Bee-O-Meter and the see: PORT innovation room.

As a result of successful partnerships, the 5G tourism community in the region has strengthened and expanded significantly and in 2019, the live operation of 5G in the area of Pörtschach / Wörthersee begun.

ZTE's Sergio Parolari Elected 3GPP RAN2 Vice Chairman

29 August 2019, Prague, Czech Republic — ZTE announced that Mr. Sergio Parolari has been elected Vice Chairman of 3GPP RAN2. This is another breakthrough of ZTE's leadership in 3GPP since Ms. Gao Yin was elected Vice Chairwoman of 3GPP RAN3 in August 2017.

As a key contributor in 3GPP for 17 years, Sergio Parolari has been a regular RAN2 delegate since January 2010. Sergio has been active in many LTE and NR topics, including carrier aggregation, dual connectivity, machine-type communications, proximity services, NB-IoT and 5G NR. Moreover, he is the rapporteur of the 5G Stage 2 specification TS37.340 on "Multi-connectivity".

Hutchison Drei Austria and ZTE Build One of the Best Wireless Networks in the DACH Region

29 August 2019, Shenzhen, China — ZTE has announced that Hutchison Drei Austria's network using ZTE equipment ranks first in terms of network quality and download speed in the DACH region (Germany, Austria and Switzerland). The evaluation was done by TUTELA, a network performance and quality assessment agency. This year, it is the fourth time Hutchison Drei Austria has been ranked as No.1.

In TUTELA's latest crowdsourcing report for Austria in July 2019, Hutchison Drei Austria has the highest consistent quality score with a percentage of 86.2% excellent and 99.3% overall basic quality samples. Hutchison Drei Austria also achieved the highest average 3G/4G download speed of 27.60 Mbps.

In previous evaluations of TUTELA, the Hutchison Drei Austria network was recognized as the best quality wireless network in the German-speaking region.

Hutchison Drei Austria's network bears more than 50% of the whole mobile data traffic in Austria, and the mobile traffic volume per SIM is the second highest in the world. However, Hutchison Drei Austria's network has still achieved excellent network performance under such high network load conditions. One of the reasons behind is ZTE's excellent product quality as well as comprehensive strength in R&D and delivery.

Telecom Egypt's Digital Transformation Journey

Reporter: Liu Yang

Adel Hamed, CEO of Telecom Egypt

Telecom Egypt has to build a very concrete base and go up step by step to reach the roof of the pyramid, which is the applications for the customers, said Adel Hamed, CEO of Telecom Egypt. Emphasizing the importance of applications, he spoke to *ZTE Technologies* about the company's shift in positioning from a total telecom operator to a total ICT provider and its digital transformation progress. Founded in 1854, Telecom Egypt is Egypt's only fixed-line operator, and one of the largest in Africa and the Middle East with a subscriber base of over 12 million subscribers. It entered the mobile market with the launch of its mobile network "WE" in 2017.

How would you characterize the trends in the Egyptian telecom market and your position in it?

Egypt, as the largest country in the Middle East and North Africa, has fiber connectivity from Egypt to everywhere. The geographical location of Egypt, the initiative, the many strengths and the strategy of Telecom Egypt positioned Telecom Egypt as the digital corridor two or three years ago. Now we are in the phase of modifying such strategy, and capitalizing on the strength, location and skilled people of Telecom Egypt and the large network to be not only the digital corridor but also the African and regional hub. Hub means we want to partner with all of the country providers, cloud service providers, serving the Eurasian market and regional market, and connecting the world.

Inside Telecom Egypt, we used to be the total telecom operator and now we are going to be the total ICT provider. ICT means a lot of industries. ICT means a lot of synergies—not only the telecom services but also total ICT services like eWallet, Fintech and media. Now we are announcing the launch of the IPTV services for our customers. This is the strength and the major point that we are focusing in the coming days.

What are the three core competitive strengths of Telecom Egypt?

One is that we are everywhere. So we have a very large, expandable, and reachable network. We reach every corner in Egypt. This is the major advantage that Telecom Egypt has. The other is the well-trained and skilled people that can offer enhanced quality services. The last one is the financial position of Telecom Egypt that enables all of the investors to see Telecom Egypt as a good environment to invest.

We have this four Es strategy. Every company all over the world has four pillars: customers, services, employees that offer the services for the customers, and at the end of the chain, shareholders that gain from such employees offering the services for the customers. The four Es strategy is excellency of services, good experience of the customers, enthusiastic employees to offer such enhanced services, and making a good equity for the shareholders.

To recap, our three major strengths are an expandable and large network, skilled and trained people, and a very good reputation and financial position that encourage investors to invest more in Telecom Egypt.

What do you think of the challenges for Telecom Egypt?

Globally, the challenge is to enhance the services and reach a very good customer experience. So the challenge is the innovations for the new markets; the challenge is to increase and expedite the network cloud so that we can achieve our goals of digital transformation, total ICT sector, and making Egypt an African hub. Now time is a challenge; now service excellency is a challenge. Out of the challenges, you have to see your weak points and strong points. Challenge does not mean obstacles; it means, for SWOT analysis,

that we can overcome such obstacles and make challenges a reality.

Where are you now in the journey of digital transformation?

We started our strategy of digital transformation as a pyramid strategy. You have to build a very concrete base and go up step by step to reach the roof of the pyramid, which is the applications for the customers. We start by building the base. The base is the network, which is a large infrastructure, a very reliable infrastructure that we build in cooperation with our partners like ZTE, one of the most efficient and committed partners. We build our infrastructure, increasing our network capabilities. This is the second step.

Then we start to implement the second phase of the strategy, which is the data center offering for the content providers and the cloud service providers. After we finish the data center, we have to go to the cloud service itself and the content itself so that we can offer something new like IPTV, Fintech. We see our roof, so we are building our pyramid to reach the roof, which is the customer needs—applications.

IT is coming. It is not only 2G, 3G, 4G and 5G. It's all about customers. To reach the customers, the relevant media includes wireless, wire, 5G and IT. Our digital transformation is the track of digital transformation initiative, track of consumer transformation, which is all of such pyramid is focusing on, and track of the government and enterprise services.

We did in the last few months a big step towards the digital transformation in the field of government. We deployed 2,500 fiber connections to the schools. This is the project of digitalizing the education environment in Egypt. And the other track with the government is digitalizing the city itself. We start with the Port Said city and finalize 600 enterprise connections to the government entities so that the government could start its initiative easily by connecting the government entities together and start to offer government digital applications like e-health, digital medical insurance. Other services for the government are coming.

We will continue our work with the government in other cities so we finalize one and sign another five and will continue for most of the cities in Egypt. To achieve such track, we have to think the new capital differently. The new capital will not only

be a smart city but also a digital city. So we have to be prepared, and we are preparing ourselves for this.

We are building our legacy, our history and building the future.

So the digital transformation encompasses various market segments.

For the market segments, it's B2C, B2B, enterprises, and government. I don't like to segment the customers. I do like to segment the services. I can offer the services segmentally to any customer. It doesn't matter whether it is an enterprise, a consumer, or maybe a new type of segment.

We are focusing on the customers by segmenting our services, putting our services in a quality manner, and offering a complete set of solutions for the customers. We started with dual offerings, now triple play services and we are now in the phase of quadruple play. We have our fixed network, and we have our broadband network. We have our IPTV and mobile services. So if I may say we are in the phase one of offering the quadruple services, for the future, it will be not only quadruple services, as I said, it will be like a snow ball rolling, eating and absorbing all of the industries.

So the banking retailer will be one of our services. If I may say it is a banking segment, I'd like to say it's banking services. Not only banking, maybe the media. We start to penetrate the media, transforming the broadcast (legendary name) to the digital TV name and now IPTV name. In the future, it will be like a one-stop shop for all the services over our large network.

The future is not for the operators; the future is for the application owners. The future is for the customers. The customers would like to have excellent services, and we are ready.

You and ZTE are cooperating in extensive areas such as 100G transmission and MASN. How would you comment on the cooperation?

It's not a vendor-operator relationship. It's a partner relationship. We start to transform this relationship through our part of digital transformation. Now we are thinking together, having a common strategy direction together, building our strategy together. It's not about technology (100G). Technology is changing everyday. So the solid base that we build our relationship is "being together with success together" as your CEO said.

How would you describe ZTE as a partner?

I would describe ZTE as a fast growing partner, ready to market and committed. In the last GSMA conference in Barcelona, I was promised that ZTE is committed. So commitment is one of ZTE's slogans. Trust was also mentioned. So if you combine commitment with trust, I believe that ZTE has a very powerful and rigid story to tell. I would now describe ZTE as a committed and trusted partner.

What are your expectations for the future cooperation with ZTE?

I have a good expectation. I believe that this expectation is achievable. By visiting ZTE Headquarters, this expectation becomes, I believe, not an expectation but a reality. I am quite sure that the coming period will be a very successful period for both of us.

As the CEO, what are your development goals for the next three to five years?

Any CEO of any company is looking for the benefits of the triangle, which is the customer, the employee and the shareholder. Putting this triangle in front of my eyes, my goal is to achieve the best ever experience for the customer, the best ever environment for the employee, and I hope I can gain the trust of our shareholders to continue the success story of Telecom Egypt for the coming two to three years. ZTE TECHNOLOGIES

Entel: Transforming Bolivia into a Nexus of Communication in South America

Reporter: Liu Yang

Hugo Fernandez Araoz, Chairman of Board of Entel

Due to a big and hilly territory and dispersion of population, in the past, Bolivia has had relatively low penetration of telecom services. But in the last few years, Empresa Nacional de Telecomunicaciones (Entel S.A.) has made great strides in increasing availability of telecom services. Hugo Fernandez Araoz, Chairman of Board of Entel, spoke to *ZTE Technologies* about Entel's recent projects. State-owned Entel is the country's biggest long-distance operator, offering local telephony, DSL and satellite pay TV services. Its Entel Móvil service makes ENTEL Bolivia's largest mobile network provider.

As the largest operator in Bolivia, could you give us an overview of Entel's achievements made over the last few years?

In the past 10 years, we have achieved the coverage of 95% of our country's territory. We have introduced fiber and increased our network and now we are able to provide services to the most part of our population. Just to give you an example, we build several thousand 4G FDD-LTE broadband mobile base stations. Also we build many sites in rural areas where there was no network before, but now in these places, people can have high-broadband network services. And these improvements give us the opportunity to increase the number of our clients in places that before we had very few.

What services or applications are most in demand in Bolivia?

At this moment, in Bolivia we are not yet concerned about the use of any specific application. Our first concern was to arrive at the home of every person of Bolivia's population. Bolivia is a very big country. We have over 1.09 million square kilometers of territory and only 11 million persons in such a big territory. Then, to have communication is the first step and a high percentage of these people are communicated by a mobile telephone, have access to broadband and receiving also television. It is the task in the next few years to amplify the use of these services.

Nowadays, operators are seeking digital transformation. What's your opinion about this trend? Will Entel take any steps for this transformation?

In the next 10 years, digital transformation will bring very huge profits, and it is a new opportunity for operators. Entel also will take some steps for digital transformation based on new technology with a goal to provide digital services. We need to work with several equipment vendors for our digital transformation and one of them is ZTE. We are happy to have ZTE as our equipment provider. It is a key partner to improve our equipment and services.

How does Entel implement digital transformation?

There is a plan to improve and to go up with this transformation. At present we are not in a hurry to implement 5G. Our first interest is to have a good communication service (4G) for all the people of Bolivia, to improve our connection to the submarine cable network, to provide cloud services not only to government but also to business community and

but also to business community and to have better communication with the surrounding countries. This means to continue to be the leader in communications area in our country.

Could you tell us about ZTE's contribution to Bolivia? What do you think of the cooperation with ZTE?

For a more focused approach we have established three regions in our country. One of these regions is devoted to ZTE, who is in charge of the working and improvement of a very big part of our network and makes sure that this region is very good connected with the two others. Beside this, we have a contract with ZTE software to improve our BSS/OSS systems. ZTE has more than 10 years of experience in Bolivia's telecom market. We are very pleased with this cooperation. We need to work together for exploring a lot of other possibilities for cooperation.

What are your prospects for Entel in the next few years and what are your priorities?

As I said before, we are working for offering cloud services for the Bolivian market the next year. At the moment, we are improving our communication with the international services by the submarine cable in the Pacific Ocean. When this project enters service this present year, we will be able to have better connectivity with all the surrounding countries and offer better and more convenient services in Bolivia.

So your prospects for Entel includes better connectivity with other countries.

If you look at the map, Bolivia is in the heart of South America. We are surrounded and have borders with five countries (Argentina, Brazil, Paraguay, Chile and Peru). Under these conditions, we have the opportunity to transform our position into a nexus of communication in the heart of South America and we are sure that we are able to do it and that we will count with the help of ZTE. ZTE TECHNOLOGIES

Zhang Jianpeng (L), SVP of ZTE, and John Hoffman *(R), CEO and Director for GSMA Ltd.*

Embracing 5G Era

Reporter: Hua Lei

5G was a major focus of MWC Shanghai held June 26-28. John Hoffman, CEO and Director for GSMA Ltd., a wholly-owned subsidiary of the GSMA, talked about the great prospects of 5G and the leading role played by ZTE in 5G development. Zhang Jianpeng, SVP of ZTE, shared with us ZTE's progress in 5G.

How do you perceive the prospect of 5G development and applications?

John Hoffman: As we launch 5G not only here in China but also around the world, we are going to see tremendous take-up of this new great technology. What I think is really interesting is that in Asia, specifically here in China, we lead the way in 5G. So we have to be prepared to showcase what great innovation comes out of this region and around the world for others to see and emulate. That starts with companies like ZTE with their great solutions deployed not only here in China but in other places where 5G is going to radically change the way we live and work. It's a great opportunity. I am super excited about it.

Up till now, ZTE has got more than 25 5G commercial contracts. Also we have started the cooperation with more than 60 partners globally. All these give us a chance to serve our customers better, and we are ready for that.

What cooperation does GSMA currently have with ZTE and what's your comment on ZTE's innovation capability in the 5G field?

John Hoffman: GSMA and ZTE have a long-standing era of cooperation. We work together on technical solutions. But not only just technical solutions, but I think it is great that we work together on long-term vision of where the industry is headed, this roadmap, the opportunity to work together for the betterment of all mobile users around the world. It's a great opportunity and one that we here at GSMA are very thankful for. Participation not only in our working groups but in our events, convening the industry as we are here in Mobile World Congress (MWC) Shanghai, MWC Barcelona and other 36 events around the world. It's a long-standing and very mutually beneficial relationship we have.

China has already issued 5G commercial licenses. How does this promote the 5G industry? Could you also introduce to us ZTE's 5G progress in the global market?

Zhang Jianpeng: The mobile technology is innovating very fast. During the past history, almost every 10 years, a new generation of technology would be applied. This year is the first year of the 5G commercialization. The initial few years of any new technology is a key period. The transition to 5G is happening faster than the 4G age. We need to pay high attention to several key points: the first challenge is the large-scale deployment; the second, the business case; and the third, the customer experience.

ZTE is a major player in the Chinese market and we treat it as our mission to develop ourselves in the 5G journey. Up to now, we've already shipped more than 50,000 5G base stations, and in as early as 2014, we started the research and applied the key technology of 5G even in the 4G age. All these help us accumulate a lot of experience in improving the customer experience and help us study large-scale deployment. I believe that such a large market as China will develop our experience in all industries and a lot of new services and business models will appear. Thus, it will help us transfer such kind of experience to all the global operators.

Up till now, ZTE has got more than 25 5G commercial contracts. Also we have started the cooperation with more than 60 partners globally. All these give us a chance to serve our customers better, and we are ready for that. We are a pioneer in 5G. We have a duty to do this great job! ZTE TECHNOLOGIES

New Game-Watching Experience in 5G Smart Stadiums

ZTE's MEC Based Multi-Angle Video Instant Dissemination Service

Fang Hui
Vice President at ZTE

5G is going to be the major driver of edge deployments. Multi-access edge computing (MEC) has strong potential and benefits in terms of reduction of network latency, localized video/data processing, and improvement in performance of video delivery and consumption, and delivery of high-quality services.

The multi-angle video instant dissemination service is designed for a typical use case where visual content is produced, processed and consumed locally, for example in a stadium environment, by considering how to maintain the low latency requirement for local video delivery and new user experience under deployments of video processing with capacity at the edge. The visual content may include video from a specific viewing angle, multiple viewing angles, slow motion replay, analytics and statistics.

Large public venues are good candidates for MEC. In this use case, video is captured from multiple sources. There may be multiple stationary cameras mounted throughout the stadium, and users may also be uploading their own captured content. Video produced from different resources are served to on-site consumers from the MEC platform, and do not require backhaul to a centralized core network and to then be returned to the user at the venue.

End users inside the stadium are provided with an APP to connect to the local video servers (vCDN) running on the edge. Consumers can select tailored content using the APP and may request a viewing angle or a shot from a location which is not available from their seat or section. Their request is directed to the MEC platform, running video applications in the stadium and at the network edge. This is especially relevant for events distributed over a wide area such as skiing and cycling. Such a case can also be events including concerts, public meetings or conferences.

The MEC platform also offers local computing capacity which executes real-time processing of the captured video streams. The video processing allows, for example, editing and composing of videos from multiple sources. The MEC system may also convert the composed video in multiple video formats in order to support the wide range of media players present in end user devices. Statistical and analytical data about a player and an actor can be fetched from a MEC server where data are locally stored, or a cloud server across the internet. Typical scenes, such as goals, corners or penalty kicks, red or yellow cards in a football game, can be recognized by using related artificial intelligence (AI) technology

and consumers are offered auto-generated video clips of the typical scenes. The edge video applications may be scaled up or scaled down dynamically, based on demand.

The APP can be integrated with other social media APPs, or have its own social function in order to share video clips, comments or user-generated videos with people outside the stadium. Apart from the video-related services, several value-added functions using edge capacity can also be added to provide convenience to on-site consumers or support venue service, for example location-based services including drink and food ordering. These functions also bring benefits and new business model to the operators or APP owners.

The multi-angle video instant dissemination service enhances the mobile experience and offers consumers with limitless video consumption. It combines multiple technologies such as MEC, IP transformation in the video production industry, low latency encoding/transcoding, video processing and editing using AI into one application. It grows up with the 5G technologies and pushes the maturation of part of the new technologies. An example is 5G broadcasts, which may be the next evolution in media delivery for mobile, as the service benefits from 5G broadcast adoptions via offloading the network loads.

Together with the operators, ZTE is embracing edge computing for both its fixed and mobile networks. Early this year, ZTE and Migu demonstrated together the design approach, with the APP installed on smartphone and pad during MWC19 Barcelona. The demo has attracted the attention of operators, and video and MEC professionals around the world.

More recently, the focus of this work has extended to an on-site trial during China's Second National Youth Games, running from 8-18 August 2019, using several competition and non-competition venues in Shanxi Province. The edge video applications will be provided by ZTE. The use of MEC will help bring more immersive and unforgettable experiences to the games, to experiencing how the world watches sport under the new 5G network. Multi-angles, virtual reality, and 360-degree panoramic live videos will bring fans closer to the action than ever before.

The 2022 Winter Olympic Games are now two-and-a-half years away. China's Ministry of Industry and Technology and the Beijing Organizing Committee for the 2022 Olympic and Paralympic Winter Games are working together to apply 5G technologies and applications during the games. The use of MEC for on-site video applications is going to be an important part of the "5G enabling smart Winter Olympics".

To meet the challenges of 5G deployment, ZTE has built a "supreme simple" network deployment, "supreme intelligent" network operation, and "supreme excellent" user experience. By virtue of high-performance chips, core technologies, a series of end-to-end products, network convergence and long-term evolution, ubiquitous artificial intelligence applications and 5G application exploration advantages, ZTE has overcome the technical difficulties such as precise and seamless 5G network coverage, coordinated development of multi-frequency and multi-mode networks, enhanced O&M efficiency, and vertical industry expansion, helping operators gain competitive advantage in the 5G era.

The coexistence of 2G/3G/4G/5G calls for site resource reuse, multi-frequency and multi-mode coordination and smooth long-term evolution. ZTE's UniSite solution features high integration, high performance, and multi-frequency and multi-mode series of base station products, making site deployment simple, economical and efficient. The UniSite solution provides differentiated match solutions for various scenarios such as urban hotspots, urban areas, suburbs and

indoor environments. This ensures seamless coverage and high network performance with the most economical investment in all 5G scenarios.

Simplifying the network architecture is imperative. ZTE NG BBU supports 2G/3G/4G/5G, CRAN, DRAN and other networking modes to achieve multi-mode network integration and smooth long-term evolution. The first commercial 5G Common Core in the industry, which is based on the service-based architecture (SBA), supports full access and integration of 2G/3G/4G/5G/fixed, is compatible with 3GPP R15 SA and NSA, and reduces the investment cost by 40 percent.

With 5G, network operation and maintenance is becoming more and more complicated, and fragmentation imposes extremely high requirements on network capability and response speed. ZTE introduces a series of self-developed AI Engine in the full 5G scenario, including fine network management based on RF fingerprint, Massive MIMO weight self-adaptation, mobile load balance to increase capacity, and intelligent shutdown to save energy and reduce consumption, thus the unattended and self-evolution network can be realized.

The supreme experience comes from seamless network coverage and supreme performance. With the industry-leading high-performance and highly integrated self-developed chips, ZTE provides the industry's most powerful NG BBU and the industry's smallest 5G AAU. ZTE has five years' experience in Massive MIMO commercialization. With continuous product performance optimization, ZTE provides commercial performance optimization solutions in various typical application scenarios (such as CBD and stadium) to provide users with optimal experience.

ZTE launched the industry's first AI-based commercial 5G slicing operation system, light edge cloud and intelligent acceleration solutions to meet the requirements of vertical industries for low-latency services. While planning 5G network construction, operators are also exploring 5G killer services for commercial rewards. ZTE focuses on large-scale fields that have urgent requirements for 5G development. They are, firstly, the industrial fields such as intelligent manufacturing, smart grid, V2X and smart Port, secondly, social governance and people's livelihood, including public security, telemedicine, water management, and smart education, and finally, the entertainment field, including UHD live broadcast and AR/VR. So far, ZTE has worked with operators and partners to implement 5G+ vertical industry applications in more than 15 fields.

By virtue of end-to-end product series and rich experience in commercial network construction, ZTE is actively participating in the commercial construction of global 5G. ZTE will work with industry partners to promote the commercial deployment of 5G to facilitate a win-win 5G era. ZTE TECHNOLOGIES

Evolution of Optical Access Network in 5G Era

Chen Aimin
Chief Engineer of ZTE Optical Access Planning

Challenges and Opportunities

As the information and communication infrastructure most crucial to the digital transformation of society, 5G will enable an internet of everything (IoE) that links humans, machines, and the environment more closely and efficiently. The resulting communication connections are convenient, superfast, intelligent, and reliable. The ubiquitous connectivity will lead to innovation and evolution in production modes, business models, and people's lifestyles.

Compared with 4G, 5G can provide stronger communication services that are classified into three scenarios. The enhanced mobile broadband (eMBB) scenario delivers peak rates of 10 Gbps. The massive machine-type communication (mMTC) scenario enables up to one million connections per square kilometer. The ultra-reliable low latency communication (uRLLC) scenario offers 1 ms end-to-end latency and can generate new applications such as the internet of vehicles (IoV).

With its increased bandwidth, reduced latency and stronger IoT support, 5G poses huge challenges for the legacy optical access network. First, for mobile broadband users, 5G boosts the bandwidth to 1–10 Gbps and shrinks the latency to 1–10 ms, which almost equals the performance traditionally delivered by fixed optical access. Therefore, traditional optical access loses its advantages over 5G in bandwidth and latency. Second, while the IoT carried by an optical access network requires gateways to operate, the 5G IoT features wide coverage, easy service provisioning and standardized interfaces while boasting simpler operation and maintenance (O&M) and lower cost.

The development of 5G also brings new opportunities to optical access network. First, 5G uses an architecture where AAU and DU are separate. In addition, because 5G operates at high-frequency bands, it requires more than twice the number of antennas (AAUs) compared to 4G. This makes the fronthaul network a crucial part of the 5G puzzle, with fiber resources being the key to 5G deployment. The existing high-density ODN can be easily connected to 5G AAUs at low cost, creating bright application prospects for

WDM-PON. Second, 5G employs high-frequency signals that has weak penetration through walls. There is also the problem of declining bandwidth and unstable access quality at the edge of a 5G wireless network. By contrast, the optical access network holds an enormous advantage in this respect because it can offer bandwidth and quality of service (QoS) that are unrelated to how far the user is from the central office.

Operators can combine the advantages of 5G access and optical access to make them complement each other. By utilizing substantial fiber resources of the existing ODN as well as stable high bandwidth access, operators can provide users with stable, reliable 5G+FTTH dual gigabit access.

Evolution Trends and Hot Technologies

To enable 5G+FTTH dual gigabit access, an optical access network needs to accommodate how wireline-wireless convergence evolves specifically in terms of planning and construction, network architecture, and technology roadmap.

When planning optical network coverage and constructing an access office (AO), operators need to consider both current service coverage and future expansion. An effective method is to establish independent integrated access areas according to the access requirements of services including fixed home broadband, base station transport, and enterprise private line, as well as in the light of administrative and natural divisions, road network architecture, and customer distribution. Each integrated service access area has a dense-coverage ODN and a converged AO where OLTs, BBUs/DUs and wireline transmission devices are deployed in a unified manner for fixed-mobile convergent access.

From the network architecture perspective, the converged AO serves as the point of presence (POP) for user access and is an important node where services are identified and steered to the cloud. A large-capacity converged AO reduces the number of AOs and allows the operator to simplify the network. The converged AO unifies service models, AO specifications, technology choices and networking plans, facilitates the evolution to SDN, and introduces AI to achieve smart O&M. This helps operators significantly simplify the construction, operation and maintenance of their optical access networks and reduce Opex.

Technically, 10G PON wireline access and 5G wireless access are introduced to deliver a bandwidth of over 1 Gbps for each user to enjoy ultimate experience of new services like 4K, 8K, VR and AR. By deploying network functions virtualization infrastructure (NFVI) to the AO and adopting multi-service edge computing (MEC) technology, low latency can be produced to enable new real-time services including VR, IoV and remote control.

To make more efficient use of ODN resources, several PON technologies based on point-to-multipoint (P2MP) architecture have emerged, including WDM-PON for 5G fronthaul and 50G PON for higher bandwidth.

WDM-PON is a P2MP architecture that uses independent wavelengths to provide each user with a rigid pipe (Fig. 1). With a maximum rate of 25 Gbps, WDM-PON meets the requirements of 5G fronthaul. Operators can deploy WDM-PON by largely reusing the existing ODN to save trunk fiber

resources. Because WDM-PON is suitable to deliver 5G coverage for dense urban areas, it is a major technological option for 5G fronthaul. At present, WDM-PON still has the problems of high cost and low reliability under outdoor conditions that need to be solved by advancing the industry chain.

Standardization of 50G PON as the next-generation PON technology was initiated by the ITU-T in 2018. 50G PON employs the single wavelength technology and is compatible with XG(S) PON or GPON. Thanks to the low-latency dynamic bandwidth allocation (DBA) technology, 50G PON can substantially decrease the upstream latency. This allows 50G PON to not only boost bandwidth for home broadband but also suit new applications including enterprise private line and 5G base station backhaul. With its ability to vastly expand the application scope of PON technology, 50G PON represents the optimal technological evolution path for operators wishing to fully use their existing ODNs.

Thoughts on Optical Access Network Construction

The key to optical access network construction in the 5G era is to develop the converged AO into an intelligent fixed-mobile convergent AO that is 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 (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 can serve 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. The NFVI is intended to ensure that low-latency, real-time services can be rapidly processed to improve user experience.
- Transport function: The AO provides network-side interfaces to centrally carry wireline and wireless traffic from the OTN, IPRAN or SPN equipment.

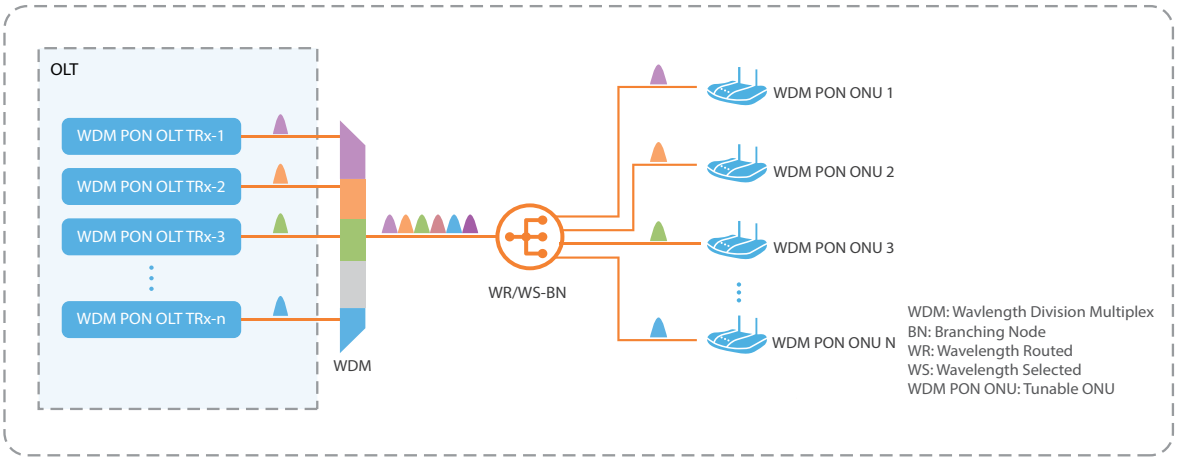


Fig. 1. WDM-PON architecture.

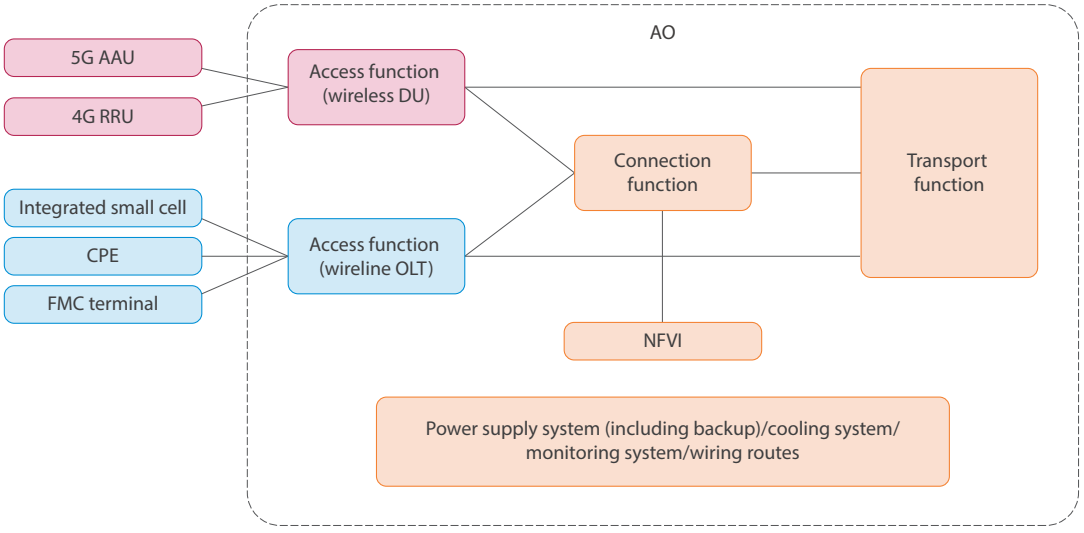


Fig. 2. Logical architecture of the AO in the 5G era.

Since AOs exist in large numbers and vary greatly in their hardware conditions and environments, transforming all of them in one stroke will incur a huge investment and an enormous workload. 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 function, connection function, NFVI (computing and storage function), and transport function in the AO can be trimmed according to service needs and smoothly expanded as per 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 without affecting the operation of existing services.

The optical access network is still of great value in the 5G era. By utilizing ubiquitous ODN resources, operators can match the size of their converged AOs with the number of users and share converged AOs and MEC resources. The converged AOs can be intelligently transformed by evolving PON technologies and introducing SDN and NFV. These measures combined will simplify service deployment and O&M.

ZTE has launched a converged AO re-architecture solution based on a deep understanding of optical access networks and broadband access services. It is also a frontrunner in the PON space by virtue of its continuous innovation in WDM-PON and 50G PON technologies. ZTE will adhere to the idea of building ultra-fast, ultra-simple, and ultra-premium networks while maintaining in-depth cooperation with operators to advance the rollout of 5G+FTTH dual gigabit access services. ZTE TECHNOLOGIES

Big Broadband: Ultrafast, Convergent, and Experience-Centric

Peng Qiang
Director of FN Product Planning, ZTE

Prospects of Fixed Broadband

As an important information infrastructure underpinning digital transformation, optical access networks are developing quickly thanks to the broadband strategies of different countries. The number of broadband users in China has surpassed 400 million with 100 Mbps access becoming mainstream by the end of 2018. The widespread use of broadband generates new services. A new generation of internet-based services featuring HD video, superior user experience, and cloudification drive increasing bandwidth demands. Currently, fixed broadband (FBB), characterized by gigabit-level bandwidth, millisecond latency and second-level service provisioning, is propelling the optical access network into a new stage of development.

Firstly, FBB is developing into a public infrastructure. With the rapid increase in bandwidth, the widespread use of FBB services and the gradual decrease of tariffs, users will become increasingly unaware of FBB's existence when they use it, although they do find it indispensable when it is not available. FBB becomes as integral as electricity, water or gas.

Secondly, in the coming 5G era, the boundaries between FBB and mobile broadband (MBB) are blurring as services converge. Wireless and wired networks are integrating at the core network, service, O&M, and transport layers, and at the access layer, they share resources and complement each other. MBB allows roaming, but it is limited in access rates, susceptible to interference, and has low bandwidth and unstable access quality at the network edge. In addition, the base stations incur high electricity costs (at least 15 percent of operator's OPEX), which will become more pronounced when it comes to 5G. FBB offers high-speed, stable access, and has relatively low construction and operating costs, but it is incapable of roaming. It is obvious that FBB and MBB are complementary. FBB and MBB are converging in terms of user experience, interaction and content; and home network traffic is increasingly generated by mobile devices. With their driving forces coming close, FBB and MBB will live in symbiosis. Since 5G presents higher requirements for network construction and operation, FMC is becoming the trend to reduce network deployment cost and enable resource sharing.

Finally, the core value of FBB is shifting

from "bandwidth" to "experience". As broadband becomes a public utility, the previous business models centered on bandwidth-based charging are losing relevance. ICPs around the world are trying to grow the revenue with targeted experience packages and create extra business value through experience optimization.

Three New Features of Big Broadband

As the access network enters a new development stage, operators urgently need to build a new-generation access network—big broadband—that enables ultrafast speeds, convergence, and a premium experience.

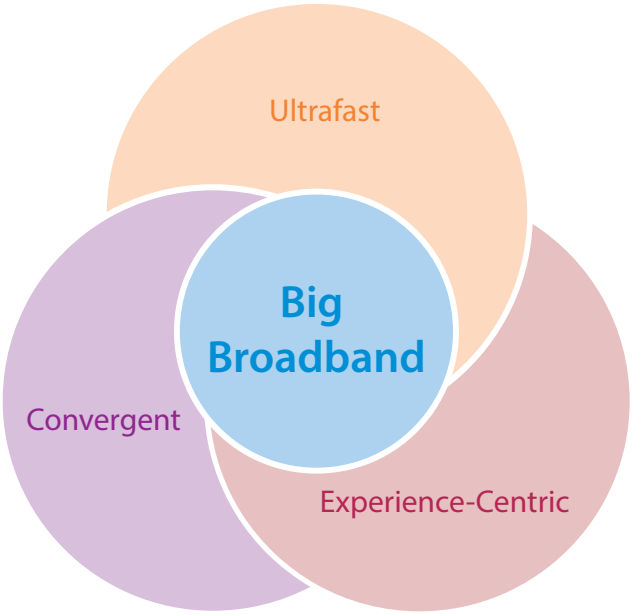
Ultrafast

It is inevitable for operators to continuously improve broadband speeds so as to deliver higher bandwidth services and gain a first-mover advantage in the fierce competition.

The life cycle of each generation of FBB technologies is about 10 years. The opportunities for gigabit networks have come. Home gigabit access technologies like 10G PON are starting to be commercially deployed and operators are considering building ubiquitous broadband access networks.

On the industry chain front, multiple gigabit technologies have matured with reduced costs, making them fit for scaled commercial deployments. Technologies such as XG(S)-PON/Combo PON/NG-PON2 can be deployed in the central office, FTTH or G.fast (if copper resources reused) on the user side, and gigabit Wi-Fi in the home, thus building an end-to-end gigabit network for new high-bandwidth services including 4K/8K, VR/AR, interactive video, and HD videoconferencing.

On the network construction front, considerations should be given to costs and smooth evolution capability. A 10 Gbps central



office network can be built first. Combo PON solution can be deployed in the OLT to provide 10G broadband services while being compatible with existing GPON services. Terminals on the user end can be gradually upgraded to gigabit as needed. This approach both ensures the competitiveness of broadband and protects operator's investments. Combo PON is the best technology option for 10G PON deployment in both greenfield and brownfield scenarios. It fully reuses the existing frame and cable resources without the need for installing new frames and racks. Its fully integrated structure reduces equipment footprint. With Combo PON, GPON ONUs and 10G-PON ONUs can coexist, and the existing ONUs can be upgraded on demand. These help operators maximize their return on investment.

Convergent

The future networks should be flexible, open and scalable to meet the increasingly high requirements put by new services. While telecom networks are tending towards a cloudified multi-tier data center architecture, the access network needs to provide capabilities of edge cloud infrastructure and enable NFV on the access side. Additionally, the arrival of 5G accelerates the convergence of services and networks. Users are concerned with service availability and experience instead of networks and access modes. The convergence of the existing fixed access and mobile transport networks will be an important direction for network development.

ICT convergence, as represented by SDN/NFV, has advanced rapidly in recent years. The stability of CT and the flexibility of IT will together make network architecture flatter and more open. In the future, networks will undergo a data-center-centric cloud transformation. The access network should follow this trend to implement phased virtualization. By deploying light-cloud blade servers in access equipment and turning them into the edge cloud infrastructure, operators can easily realize access-side VNFs, edge computing, and service provisioning closer to the users, thereby reducing pressure on the upper-layer networks and data centers.

As the 5G deployment accelerates, operators begin to plan 5G network construction. For greenfield and hotspot areas, operators favor the C-RAN

architecture with centralized DUs. However, the current direct fiber connection solution for C-RAN fronthaul consumes considerable fiber resources, resulting in high deployment costs. Operators needs a highly efficient and reliable solution to address this problem. FBB has abundant fiber resources with tree typologies, and fixed and mobile networks naturally overlap in their coverage areas. Compared with the traditional direct fiber connection scheme, using WDM-PON to carry fronthaul services for 5G macrocells or 5G indoor distributed antenna system (DAS) saves trunk fibers by at least 90 percent. With 5G sharing the fiber infrastructure with FTTH/D applications, network construction costs can be reduced and network utilization improved. In residential communities where 5G wireless and optical broadband co-exist, FBB and MBB services can be deployed on demand. 5G+FTTH smart home gateways can be introduced to make FBB and MBB complement each other. The mutual backup between 5G and FTTH guarantees always-on broadband connection and enhances user experience.

Experience-Centric

As the user requirements for broadband networks are transitioning from high bandwidth to a superior service experience, more and more operators are making user experience a strategic priority and aligning themselves to an experience-centric operating model. Big Broadband delivers a premium experience from three levels: home network, access network, and O&M.

At the home network level, operators can launch smart home Wi-Fi networking service to provide seamless coverage with gigabit connectivity throughout the home. By adopting the "1+N" networking mode (a single smart PON gateway plus several wireless routers), operators can expand the coverage of the home network to completely solve the problem of poor coverage in the last 10 meters in the home, thereby laying the foundation for the rollout of more home services.

At the access network level, operators can use intelligent tools to improve the accuracy of data for optical network resources and the quality of optical links, thus guaranteeing the reliability of the gigabit broadband access network.

At the O&M level, intelligent analysis and management tools based on a cloud platform make the topology and connectivity of the home network visible while also allowing for remote optimization of Wi-Fi quality. The need to focus on users and services calls for the introduction of AI and big data analytics to harmonize services and networks for the O&M. This new mode of smart O&M enables the visualization and management of the quality of end-to-end services, identifies network fault location within seconds, and achieve a 100% accuracy in identifying users with poor QoE for proactive user experience optimization.

Summary

Ultrafast gigabit networks lay the groundwork for broadband operations, and it will be capable of refined operation that adapts to all scenarios and multiple services through IT/CT convergence, FMC upgrade, and service aggregation, further tapping the value of the existing networks. With the shift of focus to user experience, operators need to innovate business models to create a premium experience and more value for users. All in all, the next-generation access network will be ultrafast, convergent, and experience-centric. ZTE TECHNOLOGIES

Network Slicing for AN Resource Sharing and Rapid Service Development

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After a decade of rapid development, the scope of optical broadband services has gradually expanded from traditional home broadband access to multi-ISP/ICP access, wholesale or multi-tenant access, enterprise private line access, and mobile base station transport. Traditionally, access networks (ANs) are separately built and independently operated by different operators or service departments, which greatly increases the construction period and cost. A paradigm shift is needed to allow AN infrastructure to be shared to boost utilization and reduce cost. Against this background, network slicing is born.

In a telecom network, network slicing is an innovative technology used to logically divide a physical network and virtualize multiple logical devices on one physical device. The purpose is to cut overlapping investment while achieving service convergence, security isolation and differentiated services. In an optical access network, the slicing technology is mainly applied to optical line terminals (OLTs). By splitting a physical PON OLT into multiple logical PON OLTs, key network resources including access offices (AOs), OLTs and optical distribution networks (ODNs) can be shared so that services of different types and for different customers are separately operated and maintained to maximize investment value.

Application Scenarios

The main application scenarios of network slicing are multi-service shared access and multi-operator shared access.

Multi-Service Shared Access

An operator can use one OLT in an area to connect multiple service types, like fixed home broadband, enterprise private line and 4G/5G base station transport.

The operator can select a proper slice granularity according to the service operation mode, such as by upstream port, PON card, PON port, and ONU or in a mixed mode. It can also opt for slicing by upstream port, PON card, or PON port to meet the operation and management (O&M) requirements of different services. In this way, the operation support systems (OSSs) of different business departments can be independently managed to simplify the OSS development and interconnection processes including automatic service provisioning and O&M.

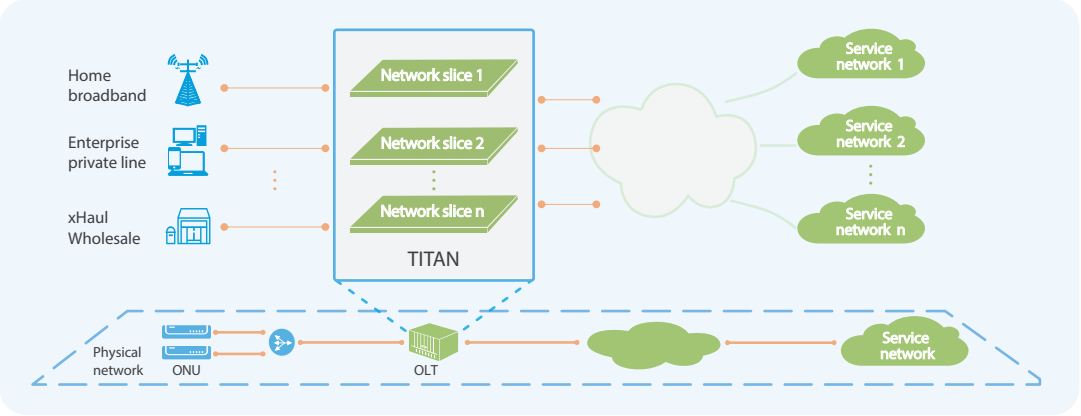

Fig. 1. Multi-operator shared OLT access.

Multi-Operator Shared Access

One OLT in an area can provide multiple operators with access services (Fig. 1). The operator owning the OLT is called the infrastructure provider (InP), and the operators sharing the OLT for service development are dubbed virtual network operators (VNOs). Based on its business model with the VNOs, the InP chooses a slice granularity, logically splits the OLT, and delivers the specified resources to the VNOs for independent operation.

To simplify O&M, the InP can use the slice granularity of PON card or PON port to interconnect the OSSs of VNOs for automatic service provisioning and O&M as well as sharing OLT, AO or some pipe resources.

To maximally share AN infrastructure resources, the InP can employ the slice granularity of ONU level to interconnect the OSSs of VNOs for automatic service provisioning and O&M as well as sharing more key resources such as optical fiber pipes and ODNs in addition to OLT and AO. This operation mode allows the InP to maximize its investment value while letting users choose broadband access services of a preferred operator.

Implementation Scheme

Network slicing creates multiple mutually isolated slices on one physical OLT. With the technology, resources can be allocated, reused and recycled on demand. Services can be independently deployed, operated and maintained on the slices. As a result, AN resources can be shared.

On-Demand Resource Allocation and Reuse

An OLT can be divided into physical and logical resources. The physical resource includes upstream ports, PON cards, PON ports, P2P ports, and ONUs, while the logical resource contains hardware forwarding entries such as VLAN, multicast, MAC and ACL. These OLT resources can be allocated on demand and then exclusively used by the intended slices to prevent preemption. In the early stage of service rollout, OLT owners can allocate resources according to their service plan. In the later stage, they may expand or release the resources, depending on how well the services are developed.

A network identifier, such as a VLAN ID or an IP address, can be reused by different slices. This enables business departments to plan independently without causing resource conflicts. Different slices can also use the same IP address to manage different devices.

Independent and Isolated Management, Control and Forwarding Planes

After a physical OLT is sliced, each slice has its own upstream port and user port resources. To fully isolate the services of the slices, the management, control and forwarding planes of each slice are independent of each other. This is actually an instantiation of functional entities related to the physical OLT, with different instances horizontally isolated from each other.

Each slice also has its exclusive software resources that are abstracted by the operating system, including CPU, process, database and file resources.

- Management plane: Each slice has an independent in-band management channel, management IP address, system MAC address, and configuration files, as well as its own SNMP, CLI, FTP, NTP, and NETCONF protocol entities.
- Control plane: Each slice has independent IGMP, DHCP, and dynamic routing protocols.
- Forwarding plane: Each slice has independent L2 and L3 forwarding engines and is configured with independent VLAN and MAC tables.

As a multi-instantiation of the management, control and forwarding planes of OLT significantly increases computing and storage overheads, OLT not only needs to support multi-instance slicing on the platform architecture, but also needs large-capacity memory and high CPU performance. Therefore, new-generation OLTs in the industry can basically offer slicing functionality.

Traditional service isolation technologies like VLAN and VPN just create logical channels in a physical OLT. By contrast, the slicing technology completely isolates the forwarding and control channels of different slice domains. Network attacks and device faults, such as MAC flooding, in one slice domain do not affect the other slice domains. Isolation between the management, control and forwarding planes of different slice domains is quasi-physical and therefore affords higher security. Within a slice domain, traditional VLAN and VPN can still be used to implement link-level security isolation.

Deployment Suggestions

Operators need to deploy, operate and maintain network slices in the same way as they treat physical OLTs. They need to interconnect the slices with OSS to carry out service provisioning, alarm processing and trouble ticket dispatching. These requirements are the key issues and major difficulties that must be addressed when applying the slicing technology to the existing network. What OSS functions should be developed depends on the management needs of the network. The original processes of the OLT should be minimally impacted by the development.

Selecting Appropriate IP Mode to Manage Network Slices

Most network slices can be managed through multiple or one IP address. In the multi-IP mode, the element management system (EMS) uses different IP addresses to manage different slices. It is recommended to use the multi-IP mode to add and maintain IP addresses of the slices in the resource management system, which can minimize the impact on the OSS process.

Planning and Deploying Resources in Advance

According to the business development mode, the operator should select an appropriate slice granularity, plan the physical and logical resources of the slices, and synchronize the physical resources to the OSS resource management system. If the existing network needs end-to-end slice management, the operator should develop slice management specifications for northbound instructions.

Choosing Appropriate Alarm Driver and Performance Collection Mode

In the physical OLT, alarms of all the slices can be viewed and operated, while in a slice, only alarms generated under the specific slice can be viewed and operated. In actual applications, depending on the management requirements, alarms of the physical OLT, network slice, or both can be used to dispatch trouble tickets.

ZTE's flagship next-generation optical access platform, TITAN, has diverse network slicing capabilities. With the slice granularity by upstream port, PON card, PON port and ONU or in a mixed mode, TITAN allows for access to multiple services like home broadband, multi-ISP/ICP, wholesale or multi-tenant, enterprise broadband, and mobile transport. ZTE TECHNOLOGIES

Three-Rate Combo PON Leads the Trend in 10G GPON Deployment

Wu Ying
FN Product Planning Manager, ZTE

In China, 100M fiber broadband has become popular, and the gigabit era is about to begin. China's Ministry of Industry and Information Technology (MIIT) launched the "dual-gigabit acceleration, same speed for same network" initiative in 2019 to promote fixed broadband gigabit applications. 10G GPON is the technology of choice to propel China's fixed broadband from megabit into gigabit rates. 10G GPON encompasses a range of technologies including XG-PON, XG-PON&GPON Combo, XGS-PON, and XGS-PON&GPON Combo. The evolution to 10G GPON needs to consider the compatibility with various in-service ONUs.

To solve the incompatibility of XG-PON and GPON ONUs, ZTE has proposed the innovative Combo PON technology to enable XG-PON&GPON Combo. This two-rate Combo PON technology has found popularity with operators because of its good compatibility and great ease of use. It has become the primary solution for 10G GPON deployment, and has been put into large-scale commercial use.

Currently, the XGS-PON technology has also matured. XGS-PON can provide 10G symmetric bandwidth, but XGS-PON OLTs are only compatible with XGS-PON and XG-PON ONUs. However, a large number of GPON ONUs are deployed in the existing networks. That means when the networks evolve to XGS-PON, they must be compatible with GPON ONUs. To solve this problem, ZTE has proposed the three-rate Combo PON technology to combine XGS-PON and GPON and enable smooth evolution from GPON to XGS-PON.

Technical Principle

XGS-PON&GPON Combo PON is a built-in optical multiplexing solution that supports the coexistence of XGS-PON, XG-PON, and GPON. It is also called "three-rate Combo PON", and is recognized in the industry as the best solution for smooth upgrade from GPON to XGS-PON.

Because XGS-PON and GPON use different wavelengths, three-rate Combo PON multiplexes the two wavelengths in an optical module, thereby achieving separate transmission and reception of GPON and XGS-PON optical signals. The three-rate Combo PON optical module has an embedded multiplexer, called the WDM1r, to combine and divide four upstream and downstream wavelengths needed by XGS-PON and GPON. XGS-PON and XG-PON use the same 1270 nm upstream and 1577 nm downstream wavelengths, while GPON uses the 1310 nm upstream and 1490 nm downstream wavelengths. The three-rate Combo PON optical module

implements the transmission of four wavelengths over a single fiber (Fig. 1).

Three-rate Combo PON provides compatibility with GPON ONUs. As it uses the wavelength division technology, the bandwidth of its PON port is the sum of the bandwidth of the XGS-PON and GPON channels. When a three-rate Combo PON port is simultaneously connected to both XG(S)-PON and GPON ONUs, it delivers a downstream bandwidth of 12.5 Gbps (10 Gbps + 2.5 Gbps) and an upstream bandwidth of 11.25 Gbps (10 Gbps + 1.25 Gbps).

Three-Rate Combo PON Solution

ZTE's three-rate Combo PON card has 8/16 ports. One port corresponds to two PON MACs (GPON MAC and XGS-PON MAC) and two physical channels. In the downstream direction, after two wavelengths are processed at separate PON MACs, they are sent to the optical module for multiplexing and then sent to different ONUs. XGS-PON ONU receives the XGS-PON signal, XG-PON ONU the XG-PON signal, and GPON ONU the GPON signal. In the upstream direction, GPON and XGS-PON use different wavelengths, which are first filtered in the optical module and then processed in different PON MACs. XGS-PON and XG-PON use the same wavelengths and require dynamic bandwidth allocation (DBA) scheduling in the same channel.

On the Combo PON card, the 8/16 ports are numbered to facilitate the operation and maintenance (O&M) of the OLT as well as the interconnection between the EMS and resource management system. When configuring data on the EMS, a new card type needs to be added. GPON ONU, XG-PON ONU and XGS-PON ONU are numbered in a unified manner, so that the OLT can automatically identify the ONU type and assign corresponding channels. Since one three-rate Combo PON port corresponds to both the GPON and XGS-PON physical channels, its O&M has the following characteristics:

- As one Combo PON port has two physical channels: GPON and XGS0PON, its management information bases (MIBs) must have additional performance statistics and alarm management information.
- Previously, the information of the GPON and XGS-PON channels was obtained separately, but is now gained simultaneously.
- The MIBs related to other service configuration and O&M remain unchanged.

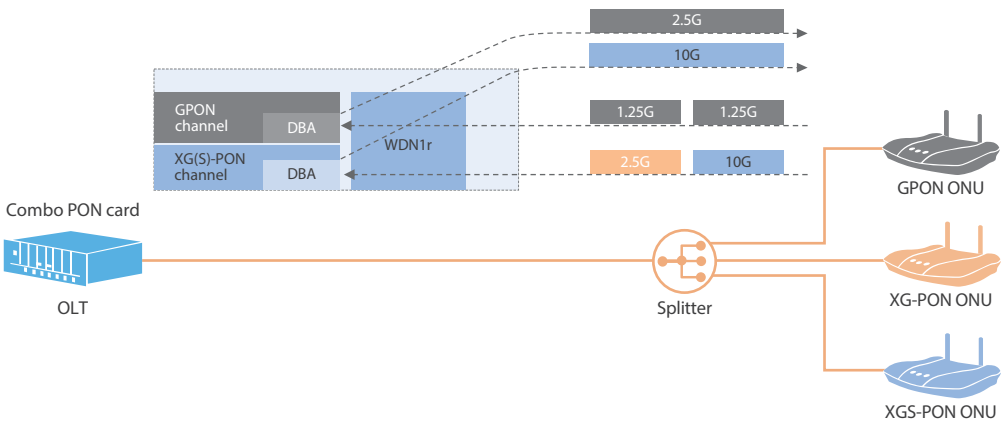

Fig. 1. Technical principle of three-rate Combo PON.

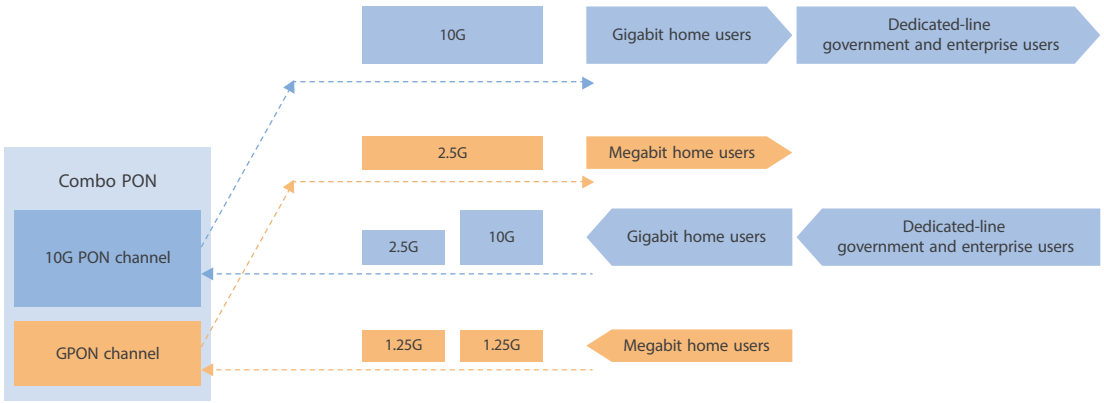

Fig. 2. Application scenarios of three-rate Combo PON.

Advantages

Three-rate Combo PON supports the access of XGS-PON, XG-PON and GPON ONUs, allowing operators to meet the requirements of different customers. XGS-PON ONUs can offer private-line access for government and enterprise private-line users, XG-PON ONUs can provide gigabit access for home users, and GPON ONUs can deliver megabit access for home users (Fig. 2).

Three-rate Combo PON with a built-in multiplexer has distinct advantages over the traditional PON solution with an external optical multiplexer:

- Easy deployment without any adjustment to ODN. The traditional PON solution needs an external optical multiplexer and the ODN has to be greatly adjusted. This would result in considerable engineering difficulties. By contrast, three-rate Combo PON employs an embedded multiplexer and requires no adjustment to ODN when it is compatible with the in-service GPON ONUs.
- No new insertion loss introduced. The issue of optical power margin can be completely addressed. An external multiplexer might add 1–1.5 db insertion loss, which would strain the already tight optical power budget of many existing networks and make the new multiplexer unfeasible. Three-rate Combo PON does not cause extra insertion loss. Using the same-class optical module, the Combo PON does not change the optical power budget margin of the ODN.
- Small footprint and simple O&M. The three-rate Combo PON optical module integrates XGS-PON, GPON and WDM1r functions, and needs no additional equipment or extra room space. This simplifies equipment O&M.
- Easy interconnection with OSS and fast service migration. Three-rate Combo PON uses the wavelength division mode. The XGS-PON and GPON channels automatically match their ONU types and can use the existing interconnection with OSS. The service provisioning process is unchanged and services are easy to migrate.

The three-rate Combo PON solution has attracted high attention from mainstream operators worldwide like Orange, Telefonica and China Mobile. ZTE is actively participating in the three-rate Combo PON tests and commercial trials with operators, leading the trend in 10G GPON deployment. ZTE TECHNOLOGIES

Light Cloud: Building a Converged Access Office to Enable Experience-Sensitive Services

Han Xiaoyu
FN Product Planning Manager, ZTE

The emergence of new services and technologies including big video, 5G, and SDN/NFV poses unprecedented requirements and challenges to access networks. In the 5G era, the explosion of data traffic calls for more network bandwidth and resources while also turning big video into a basic broadband network service. Big video is a typical experience-sensitive service that has high requirements for latency, packet loss and jitter. The content distribution and computing functions can be deployed in the access network to enable experience-sensitive services, relieve pressure on upper-layer networks and cut transmission costs. In addition, network function virtualization infrastructure (NFVI) can be introduced to the access network to support edge network clouds and edge service clouds. With NFVI, operators can implement virtual network functions (VNFs) on the access network and alleviate the pressure on the edge data centers.

Pushing edge computing to the access layer and enabling NFV-based access network require the access office (AO) to be transformed by introducing computing and storage resources and installing additional equipment. Aside from leading to AO space constraints, the transformation also incurs a high cost, takes a long period, and needs considerable manpower. With the expected benefits of NFV and edge computing still uncertain, operators lack the motivation to initiate the transformation. That makes embedding blade servers in access devices a more feasible approach because it can introduce computing and storage capabilities as desired and support NFV-based access network without transforming the AO or adding extra space.

ZTE and Intel jointly launched the Light Cloud solution at the Mobile World Congress (MWC) in February 2019. The solution loads creatively computing and storage capabilities on telecom access devices, bringing services closest to users. This satisfies

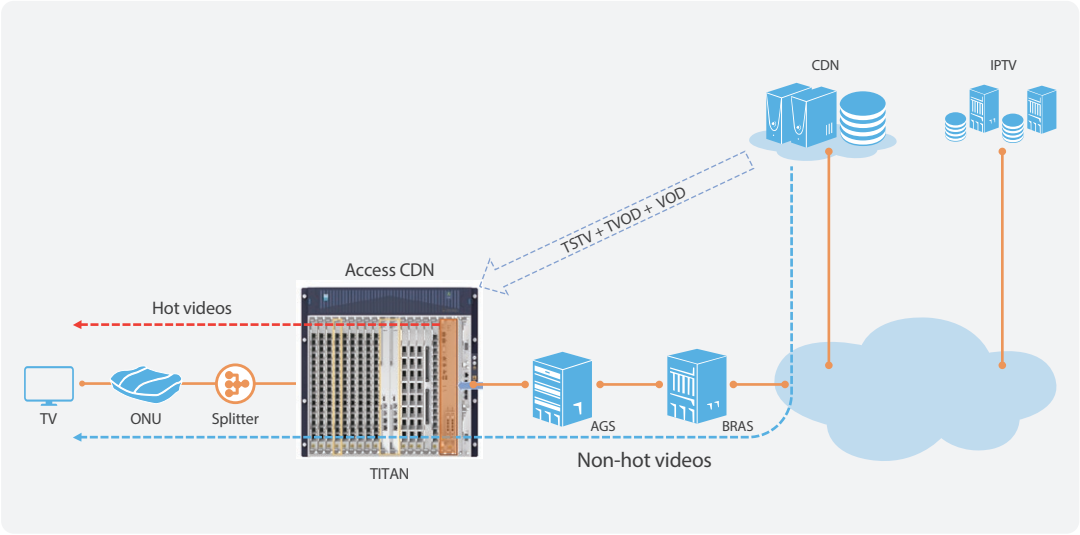

Fig. 1. Access CDN application scenario.

the needs for deploying and distributing experience-sensitive services while driving down the costs. The Light Cloud solution has three characteristics:

- **Space savings**. The 300 mm built-in blade server can be mounted in an OLT to fully use existing AO resources. No extra space is needed, and no AO transformation is required.
- **Low power consumption**. The power of a blade server is less than 200 W, which is 50 percent lower than that of a standalone server and hence saves Opex.
- **Strong performance**. The blade server uses the latest 16-core SoC CPU and provides 15 TB SSD storage, 30 Gbps content processing and 256 GB memory.

ZTE's flagship next-generation optical access platform, TITAN, supports the deployment of Light Cloud. As the industry's first fully distributed platform based on a high-end router architecture, TITAN supports access technologies from 10G-PON to 50G-PON and enables fixed-mobile convergence (FMC). Its high performance offers strong platform guarantee for Light Cloud applications.

As an enabler of multi-service edge computing (MEC), Light Cloud implements VNFs in the FMC scenario to ensure network performance and QoS, reduce the pressure on the edge data centers, and allow for the deployment of experience-sensitive services. Light Cloud can serve as Access CDN that supports high-traffic, low-latency video services to improve user experience. It can also act as NFVI to implement virtualized applications like virtual set top boxes (vSTBs) and virtual customer premises equipment (vCPE). Light Cloud employs a general computing and storage platform that can be either used by operators themselves or leased to third parties as an open infrastructure to offer more possibilities for service development.

Access CDN: Offloading Video Traffic Locally for Resource Savings

Video has become the basic broadband network service, accounting for 80 percent of network traffic. The increase in video traffic consumes a large number of backbone network resources and puts a heavy burden on operator networks.

According to the analysis and statistics, most of video contents on the web are repeatedly transmitted, especially hot videos that may form a large amount of repeatedly transmitted traffic from the video source to users in a short time. The repeatedly-transmitted video contents, including time-shifted TV (TSTV), TV on demand (TVOD) and video on demand (VOD), are stored in edge nodes of a content delivery network (CDN). If the edge nodes are located at the core router (CR) or BRAS side, which is far from users, the repeatedly-transmitted traffic will take up a large amount of uplink OLT port, OTN, BRAS, and CR port resources. The Light Cloud solution allows the CDN to be deployed in the built-in blade servers of the OLT in the AO, where it serves as an Access CDN to deliver video services, as shown in Fig. 1. In the Light Cloud solution, one blade server offers a storage capacity of up to 15 TB and a processing capability of 30 Gbps. The calculation shows that when the CDN is deployed at the CR side and the VOD traffic is higher than 3 Gbps, the CR-OLT two-level CDN architecture is more cost-effective than the CR one-level CDN architecture. When the CDN is deployed at the BRAS side and the VOD traffic is higher than 6 Gbps, the CR-BRAS-OLT three-level CDN architecture is more cost-effective than the CR-BRAS two-level CDN architecture.

vSTB: Shortening Service TTM, Extending In-service STB Lifecycle, and Optimizing Opex

Users' ever stricter demand for video experience and the increasing number of value-added services offered via STBs impose higher and higher requirements on the software and hardware capabilities of STBs. STBs that have been in service for a long time cannot meet the requirements of new services and

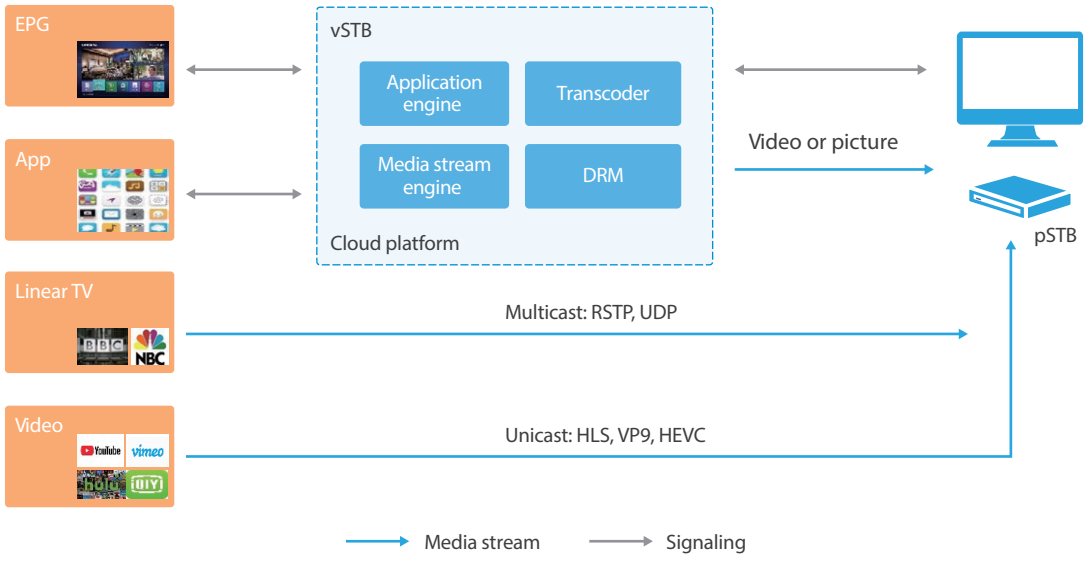

Fig. 2. vSTB application scenario.

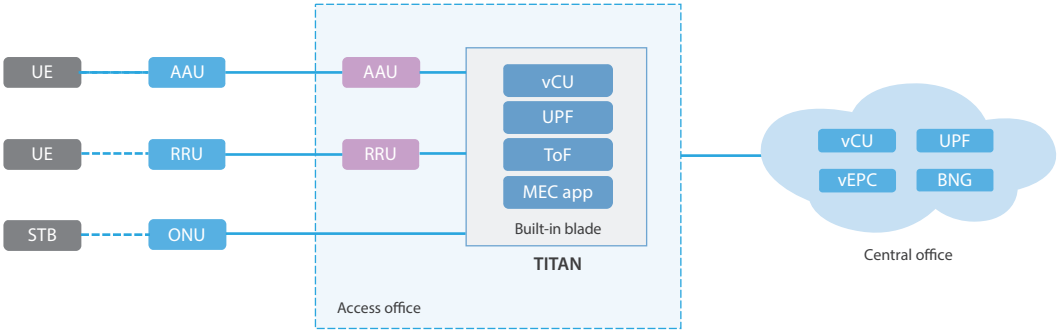

Fig. 3. MEC application scenario.

must be replaced. STBs that were deployed not long ago need frequent software upgrade to accommodate new services. Because the STBs come in numerous models and have vastly different hardware capabilities, their online upgrade and new service tests take a long period of time. That in turn slows down the go-live process of new services. To address the challenges faced by operators, ZTE has launched the vSTB solution to decouple some functions of the existing STB onto the cloud. After the decoupling, the physical STB (pSTB) implements encoding/decoding, UI presentation, and simple key operations, while vSTB performs UI/app processing, virtual services, and dynamic resource allocation. vSTB enables fast STB service deployment and upgrade. Services are only interconnected once on the cloud without the need to adapt to in-service STBs of different vendors. The services are upgraded on the cloud and take effect in real time. There is no need to wait for the upgrade of existing STBs. The compatibility between old and new STB versions is not required, which greatly extends the lifecycle of the STBs. By deploying vSTB on the built-in blade server of OLT, operators can deliver cloud-based STB services while minimizing network latency (Fig. 2).

MEC: Enhancing Service Experience

In the 5G era, the deployment of experience-sensitive services such as VR/AR, internet of vehicles, automatic driving, and industrial control demands that networks have their service capabilities optimized, content pushed near the users, and latency lowered. The trend to deliver services close to users gives rise to MEC. Meanwhile, building a converged AO that is shared by such devices as 4G baseband units (BBUs), 5G distributed units (DUs), and OLTs is now preferred by most mainstream operators. The converged AO must have the NFVI necessary for deploying MEC applications. The Light Cloud solution provides an economical and fast way of constructing NFVI in the AO. All VNFs and MEC applications can be deployed in Light Cloud on demand to form a dynamic, efficient edge computing system (Fig. 3).

ZTE's Light Cloud solution innovatively integrates IT and CT in the access network, simplifying network construction and AO transformation. It can not only meet the requirement of edge computing in the fixed network, but also provide computing and storage resources for nearby mobile services. The solution expands application scenarios of the access network and gives it new capabilities. ZTE TECHNOLOGIES

NetSphere: Easy and Smart Home Wi-Fi Networking Solution

Zhu Liangzheng
FN Product Planning Manager, ZTE

The rapid development of broadband networks is bringing more and more wireless devices into the home. Statistics from Intel and IGR show that by 2020, each home will have 50 wireless terminals on average and Wi-Fi will account for about 86 percent of the connections in the home. With the emergence of new services such as big video, online gaming, cloud storage and smart home, users demand fast, stable and seamless home Wi-Fi coverage.

The traditional networking mode, which uses a single access point (AP) or an AP plus an extender(s) to deliver home Wi-Fi, no longer meets the market requirements. Using a single AP usually produces several weak-coverage areas or dead zones. Adding APs or extenders improves coverage, but it also poses new problems, such as bad roaming, complex user configuration, weak management, and poor user experience.

The service experience of home Wi-Fi is already a concern for operators as data shows that 60 percent of the complaints from home users are related to Wi-Fi. Because no effective tools are available to locate and solve home Wi-Fi performance problems, handling user complaints is time-consuming, inefficient and costly. Operators therefore press for a visual, manageable and operable home Wi-Fi network.

ZTE has developed NetSphere, the smart home Wi-Fi networking solution, to improve the quality of experience (QoE) of broadband services for users and reduce operating expenditure (OPEX) for operators. The solution provides high-quality, seamless Wi-Fi coverage for the home with multiple APs. Employing cutting-edge technologies like mesh networking, smart roaming, band steering, and efficient O&M, the solution significantly enhances the quality of home networks and improves customer experience.

Advanced EasyMesh Architecture

In 2017, Wi-Fi Alliance (WFA) released the draft multi-AP specification for its Wi-Fi EasyMesh program. This specification defines a protocol for controlling multiple APs in a multi-AP network. The protocol performs functions like startup, configuration, control and management to enable the setup of a Wi-Fi network using APs of different vendors. ZTE's NetSphere solution complies with the technical requirements of EasyMesh V1.0.

NetSphere uses the star or tree network topology, the APs are connected with each other in wired or wireless backhaul mode, and the stations (wireless terminals including cellphones, tablets and computers) are linked to the APs via a cable or wirelessly. When the network environment changes, EasyMesh enables the APs to automatically select new backhaul links, which greatly improves the network robustness and self-healing capability.

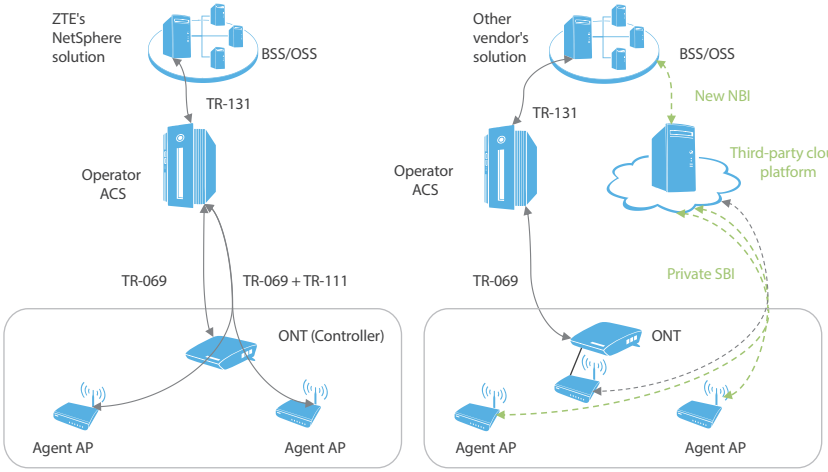

Fig. 1. Comparison of ZTE's NetSphere solution and other vendor's solution.

Smart Roaming

NetSphere supports the smart roaming technologies 802.11k/v/r, allowing a user device to seamlessly roam and switch to the optimal AP. The switching time is shortened to 10 to 300 ms, which is at least 70 percent less than that of traditional home Wi-Fi solutions and leads to a significantly enhanced service experience.

- 802.11k: The AP and the station can implement link measurement, neighbor measurement and radio frequency measurement via 802.11k.
- 802.11v: The AP can use the 802.11v protocol to require the station to roam to a specific AP (including the channel and BSSID). The station can also use the 802.11v protocol to query the destination AP of the roaming.
- 802.11r: When associating another AP on the same home network, the station does not need to negotiate another temporary key. Instead, it uses the originally negotiated temporary key to associate the target AP, thereby greatly cutting the association time and achieving fast transition.

Band Steering

The band steering technology is mainly used in dual-band APs by enabling them to switch to the less congested 5 GHz network. The switchover can happen both before and after device association, that is, the controller can require a station to connect to a designated band before the station is associated, or it can require the station to switch to another less loaded band after the station is associated because the wireless environment has changed.

By adopting the band steering technology, the NetSphere solution allows the controller to automatically assign the stations to different bands according to the signal strength, the load on the 2.4 GHz and 5 GHz bands, and the need to avoid the interference sources to achieve the optimal user experience.

Fast Deployment and Easy O&M

Compared with the other home Wi-Fi networking solutions on the market, ZTE's NetSphere solution has obvious advantages in metrics from network deployment to user experience and O&M (Fig. 1).

NetSphere can flexibly deploy the EasyMesh-defined controller role on an ONT, HGW or AP. The existing Wi-Fi-capable gateway device can be software-upgraded to assume the controller role. The controller works with Agent APs to deliver fast, low-cost Wi-Fi coverage throughout the home. In addition, NetSphere is fully compatible with TR-069 management, allowing the existing ACS platform to manage home network devices to cut O&M costs.

NetSphere has been highly recognized by operators and broadband users across the world for its cutting-edge technologies and low capital expenditure. ZTE leads the global CPE market, having deployed its CPE products in more than 100 countries and regions and counting 10-plus top-tier carriers among its customers. ZTE TECHNOLOGIES

25G WDM-PON Based 5G Fronthaul Solution

Qin Yewen
Director of FN Product Planning, ZTE

The acceleration of 5G rollout prompts operators to plan the construction of 5G transport networks. Compared with 4G, 5G imposes higher requirements for transport networks in terms of bandwidth, latency, synchronization, reliability and flexibility. As an important part of the transport network, the 5G fronthaul network needs to meet these requirements and also address the difficulty of laying optical fibers to accommodate the exponential growth in 5G base stations.

Since the C-RAN fronthaul architecture can reduce the site rental fees, maintenance costs, and power consumption of distributed units (DUs) in 5G greenfield and hotspot areas, it has gained the favor of operators. Based on 3GPP specifications and industry trends, the C-RAN fronthaul architecture has the following technical requirements:

- Data interface and rate: The standard 25G eCPRI is the 5G fronthaul interface of choice.
- Latency: Support for one-way latency requirement of not exceeding 100 μs.
- Synchronization: Support for synchronous signal transmission to meet the ±1.5 μs synchronization precision requirements for basic 5G services.
- Optical power budget: Support for the power budget of fronthauling links.
- Management: Support for device management, service configuration and monitoring, fault diagnosis, and other management functions.
- Others: For example, adopting the single-fiber bi-directional transmission technology to save optical fibers needed by the fronthaul network.

However, the current direct fiber connection solution for the C-RAN fronthaul consumes considerable fiber resources, resulting in high deployment costs. Operators need a more economical and efficient solution to address this problem.

5G Fronthaul Based on 25G WDM-PON

25G WDM-PON is an integration of WDM and TDM-PON with the following technical features:

- The physical topology is point-to-multipoint, and wavelength routing is performed by a multiplexer/demultiplexer to save optical fibers.
- The logical topology is point-to-point. The OLT communicates with ONUs through independent, mutually isolated wavelengths.
- A single wavelength supports data rates up to 25 Gbps, meeting the signal transport requirements of the eCPRI.
- The ONU is colorless, tunable to allow flexible wavelength assignment and routing, thus reducing its deployment cost.
- The AWG incurs an optical power loss of around 5.5 dBm, which is less than that of the conventional optical splitter, and supports an optical power budget for 10 km.

Under the C-RAN architecture, fronthaul via 25G WDM-PON has many advantages over other

fronthaul schemes like direct fiber connection, passive wavelength division, and active wavelength division.

- High technical suitability: The 25G WDM-PON technology meets the interface, rate, latency, and other requirements of 5G fronthaul networking. It will be put into trial commercial use in 2019-2020 to match with the progress in 5G rollout.
- Low construction cost: Many operators have built and operationalized their FTTH ODNs. By using the existing FTTH ODN resources including fibers and pipes to also carry 5G fronthaul, operators can vastly save trunk fibers, reduce the difficulty of optical cable planning and deployment as well as the overall cost of the 5G fronthaul network.
- Fast deployment: The FTTH ODN can adapt to a denser grid of 5G base stations in the future, and can rapidly provide fronthaul links through scheduling the distribution cables. The SFP ONU can be quickly deployed in the AAU without being powered on.
- Simple operation and maintenance (O&M): All the central-office devices are deployed in the access office to enable centralized maintenance and improve O&M efficiency.

TITAN-Based 5G Fronthaul Solution

To meet the requirements and challenges of 5G fronthaul deployment, ZTE launched a 5G fronthaul solution based on its next-generation optical access platform—the TITAN OLT. The solution uses premium, abundant fiber broadband network resources to achieve 5G+FTTH integration, which is a variant of fixed-mobile convergence (FMC), thereby enabling 5G+FTTH integrated service access in dense residential communities and transport service for 5G indoor distributed antenna system.

TITAN provides 12-port high-density 25G WDM-PON line cards. Each PON port is a dedicated channel with an independent wavelength, which is used for eCPRI fronthaul transport of one AAU. Up to 20 dedicated channels can be converged by a WDM combiner into a single trunk fiber. Compared with the direct fiber connection scheme, the WDM-PON solution reduces the required trunk fiber by at least 90 percent, as shown in Fig. 1. The TITAN platform provides innovative TDM-like low-latency channels that handle traffic from 5G AAUs without buffering, forwarding, routing and search processes. ZTE's self-developed core chips allow TITAN to forward fixed code blocks using shortcuts, ensuring that the OLT and ONU together introduce a processing latency of less than 7 μs for fronthaul services. When the OLT and DU are installed in the same equipment room, the system forwarding latency (including the 50 μs latency over the 10 km fiber) is less than 57 μs. That is 43% lower than the 100 μs latency required by 5G URLLC applications.

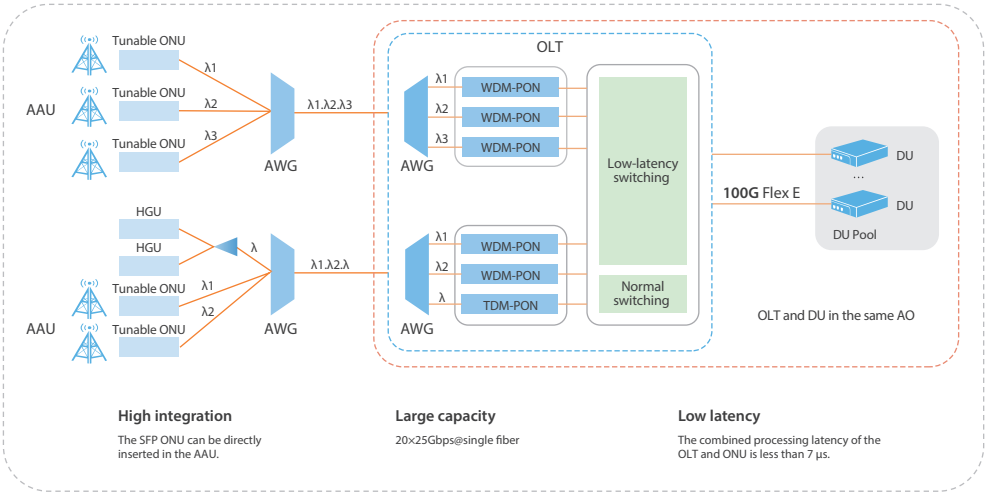

Fig. 1. 25G WDM-PON networking for 5G fronthaul.

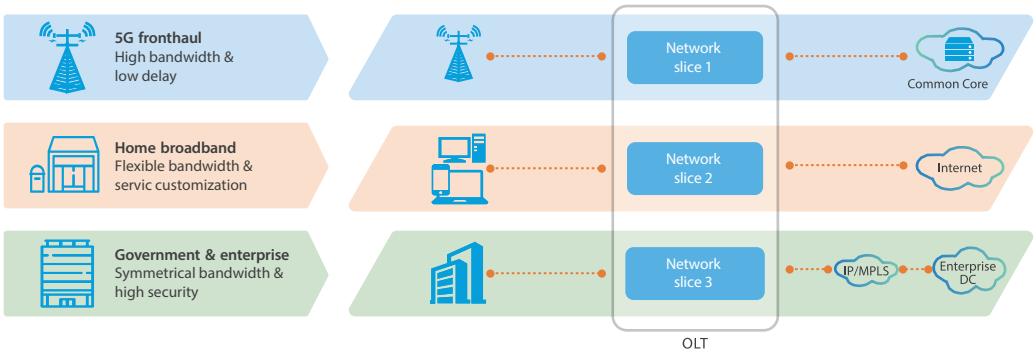

Fig. 2. Network slicing on the OLT for 5G fronthaul.

As shown in Fig. 2, TITAN supports network slicing based on service types, including 5G fronthaul service. The OLT can offer independent uplink ports for 5G fronthaul. In the downlink direction, the OLT can realize network slicing at both the PON port and PON card levels. The slicing can also be based on ONUs. All these mechanisms enable rights- and domain-based management as well as differentiated QoS assurance for 5G fronthaul.

Meanwhile, ZTE has introduced an innovative solution that embeds blade servers in the PON OLT platform to support latency-sensitive services. TITAN is the industry's first PON OLT platform that contains built-in blade servers. As a network functions virtualization infrastructure (NFVI), the blade servers can be used by the operator itself or leased to third parties. Meanwhile, they provide edge computing capabilities for both mobile and fixed services, can be leveraged to cache and accelerate 5G real-time video services or deliver more value-added services in the future to improve quality of experience (QoE) while reducing pressure on the data centers. The TITAN-based solution for carrying 5G fronthaul over 25G WDM-PON has the following highlights:

- Fiber savings: The FTTH ODN is reused to save least 90 percent trunk fibers.
- Low latency: Innovative TDM-like low-latency channels ensure a processing latency of less than 7 μs in OLT and ONU, which meets the latency requirements of 5G URLLC services.
- Easy management: Independent network slices are provided for 5G fronthaul to enable rights- and domain-based management as well as differentiated QoS assurance.
- High scalability: The built-in blade servers provide edge computing capabilities for multi-service access. They can serve as an NFVI to enable FMC, thereby helping operators achieve network and operation transformations.

ZTE's Contribution to the Industry

ZTE is a major contributor to WDM-PON standardization. In June 2017, ZTE became an editor of ITU-T G.sup.5GP whitepaper to promote the PON-based 5G fronthaul technology. In December 2017, ZTE held a joint conference for FSAN and ITU-T SG15 Q2 to discuss solutions for 5G fronthaul over WDM-PON. In February 2018, ZTE became an co-editor of ITU-T Recommendation that specifies bidirectional single-fiber point-to-point systems oriented to 5G applications. Meanwhile, ZTE is committed to advancing the development of the 25G WDM-PON optical component industry and has in-depth technical cooperation with leading optical module manufacturers.

ZTE works closely with operators to promote specification formulation and technology validation. In December 2018, ZTE and China Telecom jointly completed the industry's first validation of 5G fronthaul over N×25G WDM-PON on a live network in Suzhou. The validation covered many metrics including transmission performance, automatic wavelength tuning and delivery, and long-time stability. The N×25G WDM-PON devices could be connected to 5G DUs and AAUs that support standard eCPRI interfaces. The combined processing latency of OLT and ONU was as low as 7 μs, which well met 5G requirements for ultra-low latency. As demonstrated by the validation, 25G WDM-PON could carry 5G fronthaul services stably and transparently, with the data rate and forwarding latency equivalent to those in a point-to-point direct fiber connection.

Moving forward, ZTE will continue to work with industry partners to promote the improvement, maturation and commercialization of the 25G WDM-PON technology. ZTE TECHNOLOGIES

Telkom: Exploring a Path to FTTM in Indonesia

Telkom is the Indonesian state-owned telecom operator offering enterprise, mobile (via its Telkomsel brand), home (mostly via IndiHome), wholesale, and international (via WIB) communications services. Telkom is the perennial leader in the country's fixed and mobile telecom markets.

Major operators across the globe have been advancing their digital transformation in recent years. Telkom also seeks transformation by focusing on digitalization (developing and deploying digital services), optimization (enabling more agile and efficient operations) and experience (bringing the best user experience).

Initial Achievement in Optical Access Network Construction

Telkom's home services grow fast under its IndiHome brand. Since 2009, Telkom and ZTE have started a close cooperation to provide high-speed connectivity services through fiber-to-the-home (FTTH) deployment and diverse video services using ZTE's IPTV platform. This greatly enhances user satisfaction, expanding Telkom's subscriber base to more than 4.7 million. Accounting for 64% of home service revenue, IndiHome has become Telkom's star brand service.

Amid a rapidly developing broadband market, Telkom launched a large-scale FTTH construction in 2009 to provide users with higher bandwidth and better service experience. After nearly ten years of development, Telkom has boasted an optical distribution network (ODN) with a coverage capacity of around 16 million lines. The vast fiber resources have given Telkom huge advantages in business operation and have further boosted its IndiHome brand. To accelerate its digital transformation, Telkom has also actively explored fiber-to-the-mobile (FTTM) deployment that can quickly expand mobile backhaul transport services while fully utilizing existing fibers.

Su Honghai
FM Product Planning Manager, ZTE

FTTM Analysis and Implementation

FTTM relies on a passive optical network (PON) to deliver the backhaul from wireless base transceiver stations (BTSs) to the transport network. It brings significant advantages to fixed network operators who have substantial fiber resources, allowing them to use the resources to expand new services. FTTM has high requirements for transmission metrics including clock synchronization and QoS assurance.

Multi-Service Transport

2G, 3G and 4G BTSs coexist in Telkom's existing network, and their service bandwidth and interfaces are different. 2G BTSs use E1 interfaces, while 3G and 4G BTSs adopt GE/FE interfaces.

ZTE's FTTM solution is compatible with the in-service BTSs and ensures smooth network evolution. By allowing TDM services to be carried over a PON, the solution can make full use of existing fiber resources.

Frequency and Time Synchronization

The Telkom network meets the technical requirements of synchronization. Clocks are imported through Metro-E, synchronization data is transferred over GPON, and the baseband units (BBUs) resolve the synchronization data for BTSs.

Timing information is transferred over PON. The network reference clock is input from the OLT side and after being traced by a phased-lock loop, acts as the public clock source of the entire PON. The local system clocks of ONUs are synchronized with the clock source. The PON ranging mechanism supports IEEE1588 v2 protocol, providing high-precision frequency and time synchronization for the BTSs connected to ONUs.

QoS Assurance Mechanism

BTSs require the transport network to have traffic classification, service differentiation, and bandwidth multiplexing capabilities. ZTE's FTTM solution enables GPON to differentiate services and set proper priorities for them to guarantee their respective bandwidth. Commercial verifications show that GPON has strict QoS assurance. For one-way end-to-end traffic, the transmission delay is less than 50 ms, the delay jitter is shorter than 10 ms, and the packet loss ratio is lower than 1%. In the signaling plane, the transmission delay is less than 100 ms, the delay jitter is shorter than 10 ms, and the packet loss ratio is lower than 0.1%.

Network Reliability

BTSs also require the transport network must meet carrier-grade reliability requirements. Protection switching should take less than 50 ms to complete so that services can be rapidly recovered without affecting customer experience. PON is a typical tree topology and supports type B/C protection in the FTTM solution.

Compared with traditional IP transport, FTTM not only meets basic mobile backhaul requirements such as QoS, synchronization, multi-service transport and high reliability, but also has advantages in terms of simple topology, ODN reuse and fast site activation.

Commercial FTTM Deployment

Telkom has deployed ZTE's FTTM solution to achieve integrated access to TDM and IP data. The commercial FTTM has become the world's largest GPON-based integrated network for mobile backhaul and fixed access and also the industry's first GPON transport network for all service scenarios.

The FTTM solution employs ZTE's multi-unit access terminals including F820 and F829 to connect to the Node Bs and BTSs in the downlink and the OLT in the uplink. From the OLT, the uplink connection extends to Metro-E and IP/MPLS networks (Fig. 1).

Currently, Telkom's mobile transport network contains about 180,000 BTSs of different standards, and roughly 30% of them are backhauled through a GPON. The successful implementation of the ZTE FTTM solution won a high recognition from Telkom. With its deployment still expanding, the solution will help Telkom further increase the utilization of its GPON network.

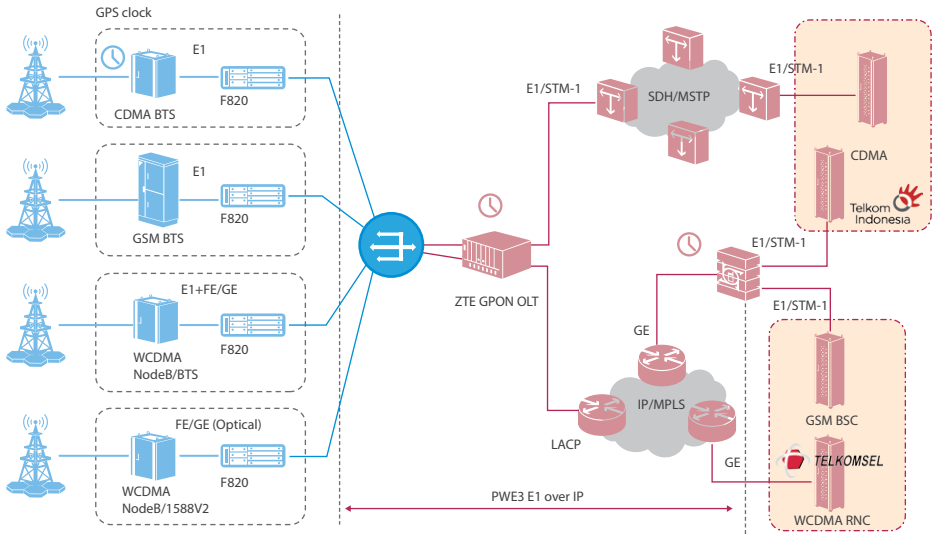

Fig. 1. Telkom's mobile transport network.

Exploring New 5G Applications of FTTM

With the advent of the 5G era, Telkom, as a telecom industry leader, is also actively building its presence in the 5G landscape. Telkomsel, a Telkom subsidiary, already carried out 5G tests in 2018. The three typical scenarios of 5G—eMBB, mMTC and URLLC—all depend on the support of optical networks. Moreover, as 5G networks aim to provide a higher-speed experience for a denser crowd, BTSs will be smaller and deployed increasingly closer to end users. That means more fiber resources will be needed in the 5G future. Therefore, being a stable and economical transmission medium, optical fibers can greatly meet the transmission needs of customers in the 5G network architecture.

25G WDM-PON will be a better solution for 5G FTTM fronthaul, and its related technical standards are being formulated. The solution has many attractions.

- Multiple channels: WDM PON supports 20 pairs of wavelengths, and a single PON port can connect to 20 active antenna units (AAUs).
- PON: Passive optical network and passive components can reduce costs and improve O&M efficiency.
- P2MP: The point-to-multipoint tree topology can save trunk fiber resources.
- Colorless ONU: A colorless ONU can be flexibly deployed to provide high-quality, big-bandwidth and long-haul transmission.

TITAN, ZTE's flagship new-generation OLT, supports various PON technologies. TITAN delivers both 5G fronthaul and backhaul services, and is also compatible with 3G and 4G services. It supports P2MP 10G PON/50G PON or P2P transmission in the downstream direction and provides n×100GE or OTU4 interfaces in the upstream direction. Telkom can use TITAN to upgrade its existing 4G LTE sites to 5G and backhaul its 5G services.

TITAN can also offer enhanced functions like MEC, network slicing and SDN/NFV, providing stronger technical support for Telkom's 5G rollout down the road. At present, Telkom has completed the first-phase test with TITAN. With its new architecture and technologies, TITAN will soon be ready for Telkom's 5G deployment.

Telkom's large-scale commercial deployment of FTTM is a good example of successful FTTM application, because it fully reuses fiber resources of home broadband and simplifies network while ensuring service quality. As long-term partners, Telkom and ZTE keep exploring new technologies and solutions together to help Telkom lead the 5G race. ZTE TECHNOLOGIES

To enable connectivity and trust everywhere