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ZTE TECHNOLOGIES

VIP Voices

Drei Austria's Pioneering Journey to 5G in Austria

Expert Views

50G PON: New-Generation PON Technology After 10G PON

Special Topic

Fiber Transformation

Cover Figure | *Rudolf Schrefl, CEO of Drei Austria*

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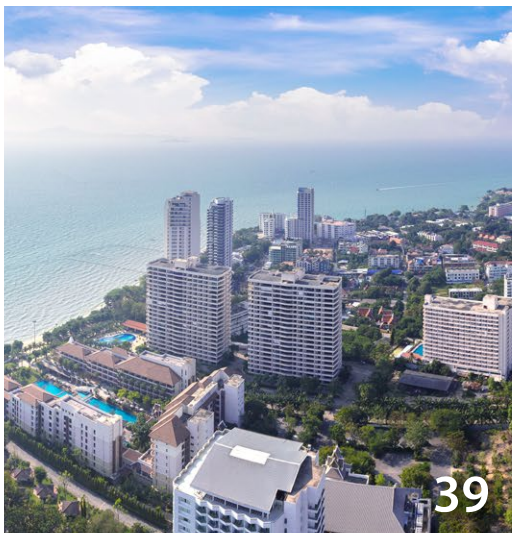


Success Story

Rudolf Schrefl, CEO of Drei Austria

Drei Austria's Pioneering Journey to 5G in Austria

Reporter: Ma YongXiang

Drei Austria created another first on its way to 5G when it started the first 5G SA trial in Austria in June. Rudolf Schrefl, CEO of Drei Austria, talks about the company's 5G journey as well as the latest updates on its 5G progress.

ZTE and Drei Austria have already a long lasting and very successful joint journey. But with 5G we together pushed this to the next level. Please elaborate your view of the Drei Austria 5G success.

With ZTE as a partner on the 5G journey of Drei Austria, we together were able to—two weeks after we acquired the frequency—perform the first public 5G NSA call, followed by the first continuously covered 5G region in Austria in line with the first commercial tariffs on 5G in Austria not even three month later in September 2019. From March to November 2020, we have completed core network commissioning and debugging, acceptance test and access network cutover successfully one and half months earlier than planned, by applying the ZTE pandemic-driven Digital Remote Delivery & Deployment Process. Meanwhile, 5G NSA is widely deployed and used, even on 5G Campus Networks, and we could prove our outstanding performance in the latest CHIP network test in May 2021 where we achieved an "A" grade.

Jointly with ZTE our reliable partner, we provided high-quality services when the world needed them most and will continue to do so.

So 5G really arrived in Drei Austria? What are your next plans?

Yes and No. 5G NSA is widely deployed

and is already successfully used in our customer base, but we will not rest on our laurels. In 2020, Drei Austria and ZTE started in our joint innovation lab, the next step to the future. We were able to tailor 5G SA to our needs and the market needs and have very soon a product ready on 5G SA. We started in June 2021 the first 5G SA pilot system in Austria, running on a new telco ecosystem and supporting enhanced end customer services like eMBB, mMTC and uRLLC including network slicing and mobile edge computing.

Drei Austria follows clearly the vision of leading 5G development in Austria, including leading to deploy 5G commercial network, leading to provide 5G service and leading to develop 5G ToB. We aim to provide top-quality service for both family and enterprise customers and promote the digital transformation of vertical industries.

You mentioned "a new telco ecosystem supporting enhanced end customer services". What do you mean by that?

We see 5G SA not only as a telecommunication technology, but more as a full ecosystem enabling digitalisation of our company same as of our customers. This ecosystem includes the 5G technology, virtualisation, automation and the integration to applications, to ensure an efficient, tailored, outstanding and high-performance end customer service.

To unleash the full power of this ecosystem we together modernized and simplified the network, introduced a unified cloud platform and enhanced the functional scope of the E2E architecture for a at least 10 years future-proof network.

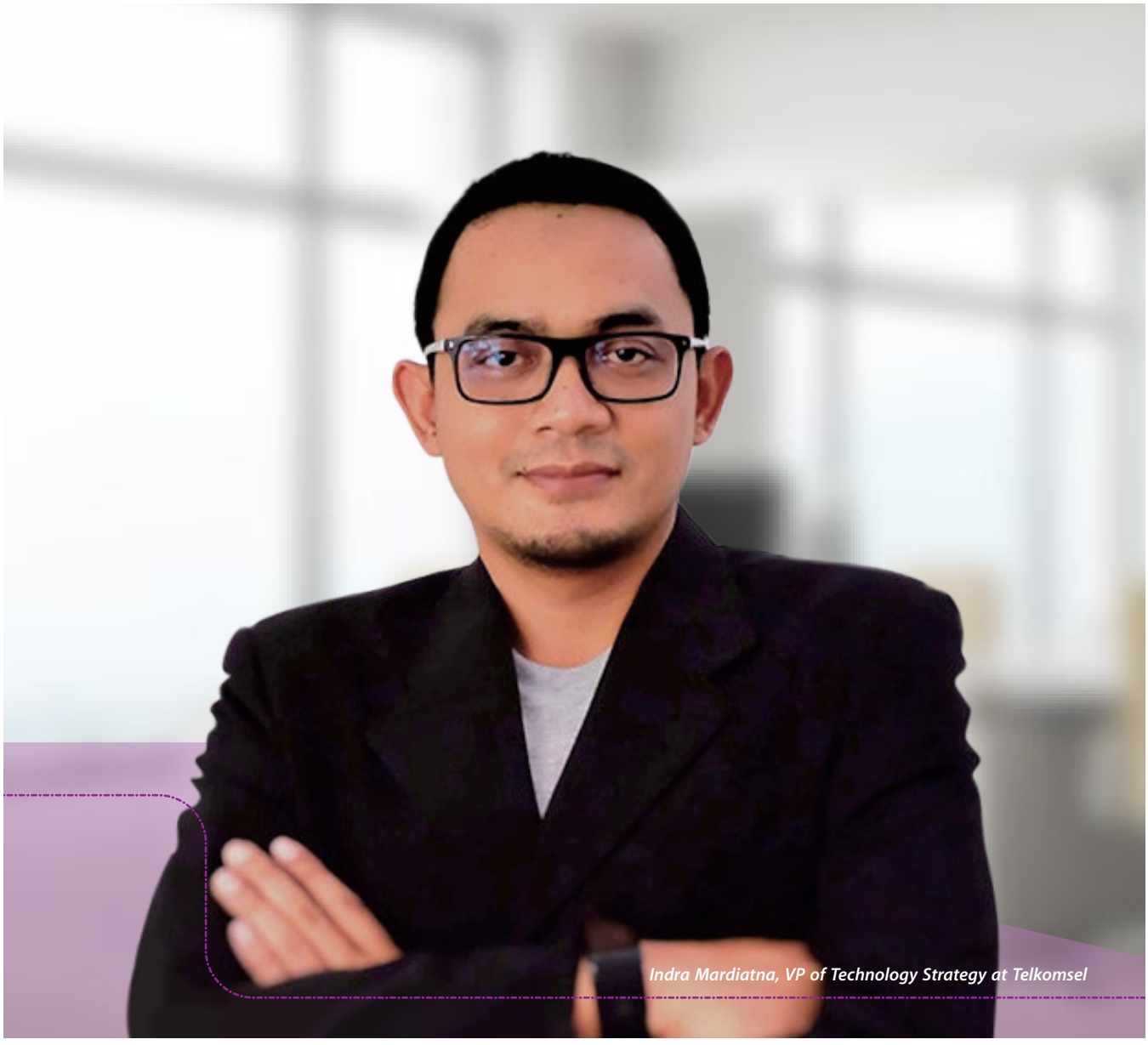
On top of this we will launch future-oriented high quality business and service innovations. For consumers, we have 5G-FWA, 2K/4K video service, service slices and innovative tariff models with diverse data traffic, data rate both DL and UL and content based tariffs. For businesses, we enable smart building based on QCell + MEC, 5G Industry 4.0 cooperation with Technical University of Vienna, and the innovative 5G bee-o-meter project to improve the bee's ecological environment.

What are your expectations and visions for future cooperation with ZTE?

We continue to regard ZTE not only as a supplier, but as a partner who is aware that the quality of the equipment and technologies are the basics for outstanding end customer services, and those are the key success factors in the Austrian market. We expect that ZTE will continue to develop and provide high-quality, future-proof and innovative network equipment, end devices and functionalities for the future. We wish to continue the close dialogue between our experts who plan, operate and optimize our network with ZTE's R&D teams in a very open and constructive manner we have jointly established and benefited on both sides. ZTE TECHNOLOGIES

Telkomsel: Spearheading 5G Development in Indonesia

Reporter: Shena Agusta



Indra Mardiatna, VP of Technology Strategy at Telkomsel

In May, Telkomsel launched the first 5G service in Indonesia, furthering its commitment to advancing the digital nation. In an interview with ZTE Technologies, Indra Mardiatna, VP of Technology Strategy at Telkomsel, talks about how the company has prepared for 5G deployment and how it will move forward with 5G under its vision.

Telkomsel has been in the leading position in Indonesia. And the recent commercial launch of 5G technology has proved so. What is Telkomsel's take on 5G?

As the leading digital telco in Indonesia, Telkomsel is committed to offering the best products, services, and solutions through collaborative efforts with partners and other stakeholders. By being the first 5G operator in Indonesia, we have revived our commitment to advancing Indonesia's digital ecosystem.

The implementation of Telkomsel 5G will reinforce our digital capabilities. 5G will enable us to provide leading solutions to improve user experience, transform industries, and level up the quality of life of people in Indonesia. We dedicate the deployment of Telkomsel 5G to opening up millions of opportunities for consumers, B2Bs, and academics.

How has Telkomsel been preparing the commercial deployment of 5G in Indonesia?

Telkomsel has been running a variety of technological trials and use cases since 2017 when we had a 5G live demo. The following year, during the 2018 Asian Games, we built the first 5G experience center in Indonesia. At that time, we introduced 5G technology through Autonomous Vehicles, Cloud Gaming, VR, and many more.

We didn't stop there. We have also been expanding 5G use cases to a broader sector in diverse industries to

encourage the Making Indonesia 4.0 just like when we hosted the 5G for Industry 4.0 in Batam back in 2019.

On that occasion, we had a collaboration with B2B partners to demonstrate the concrete application of 5G technology, from smart factories, smart ports, smart agriculture to remote monitoring. All of them will help industries simplify business processes and accelerate efficiency and productivity.

Those kinds of trials and use cases are part of our plan to roll out the best practices of 5G technology according to customers and industries' needs in Indonesia. Of course, we have been working closely with the government of Indonesia to make 5G a reality. The moment we earned the commercial operation permit to roll out 5G technology from the Ministry of ICT, we realized that it was a great opportunity to reinforce our leadership in mobile technology and foster Indonesia's digital transformation through 5G.

Could you share with us about Telkomsel's 5G rollout plan?

Telkomsel envisions that anyone can experience the best 5G service supported by a reliable 5G network. As the first 5G operator in Indonesia, we will continue to make a thorough effort in expanding the availability of Telkomsel 5G services.

In the future, 5G will accelerate the digital lifestyle of the community and digitally transform local governments, MSME players, and cross-industrial sectors that will increase productivity, drive efficiency, and deliver more innovation. Telkomsel 5G demonstrates our commitment to liberating digital connectivity as the foundation of an inclusive and sustainable national digital ecosystem.

Therefore, we continue to establish strategic partnerships with multiple parties to create a positive impact that answers the growing needs of communities and industries. We will take this opportunity to contribute more to the progress of the nation through leading innovations.

You mentioned that Telkomsel took part in the Making Indonesia 4.0 roadmap. How does Telkomsel play a role to navigate this roadmap to the right direction?

Telkomsel fully supports the government's vision to maximize the use of 5G technology in many sectors by providing the leading 5G service in Indonesia.

We will continue to strengthen our collaboration with many players across industries. In this way, we can ensure that 5G applications in the industrial sector will create innovative and beneficial solutions that bring convenience and added value to the community in everyday life.

We are pulling all efforts to make 5G a driving force for the nation's progress. We are on the right track to move Indonesia forward at the global level.

As we know that Telkomsel and ZTE's collaboration is close and tight, and may I have your perspective about ZTE? Any suggestions for ZTE?

It wouldn't be possible to roll out 5G without full support from our strategic partners, including ZTE. We work closely with ZTE to showcase several 5G use cases at the recent 5G launch event, demonstrating 5G benefits for both consumers and enterprise segments, such as the 5G VR experience and 5G patrol robot. We will continue this partnership to provide a better mobile broadband experience for our customers. ZTE TECHNOLOGIES

50G PON: New-Generation PON Technology After 10G PON

Wang Xinsheng
Chief Engineer of FM Product Planning, ZTE

Development of PON

PON is a broadband access technology based on an optical distribution network (ODN). It uses a P2MP topology, has independent upstream and downstream transmission wavelengths, and transmits data in time division multiplexing mode. The ODN between the OLTs and ONUs utilizes only optical fibers, and is passive throughout, highly environment-adaptive, and easy to expand and upgrade. Over the past decade, PON has been put into large-scale deployment thanks to its advantages over copper technology in terms of fiber, P2MP and passive nature.

The development of PON is largely promoted by the standard organizations ITU-T/FSAN and IEEE. GPON and EPON are massively deployed today to provide users with up to 100 Mbps access bandwidth. Newer 10G PON technologies (10G GPON and 10G EPON) have also been commercially deployed on a large scale, delivering a bandwidth of up to 1 Gbps to support scaled deployment of 4K/8K videos and the introduction of VR/AR in the early stage.

50G PON: The Next-Gen PON Technology After 10G PON

Video has become a basic service carried by broadband networks. The application of PON technology is extending from home broadband to enterprise domains such as telemedicine, smart manufacturing, and factory or mine communications. These developments pose higher requirements on network metrics, including bandwidth, latency, packet loss, jitters, QoS, and user experience. For example, VR service requires more than 1 Gbps bandwidth and an RTT of 5 ms while telemedicine demands an end-to-end latency of less than 50 ms and jitter less than 200 μs.

To meet service requirements in the era after 10G PON, the IEEE and ITU-T/FSAN started to research the post-10G PON technology after finalizing the 10G PON standard. The next-generation PON will mainly develop in two directions: improving the single-wavelength rate or increasing the total rate through multi-wavelength multiplexing. The industry consensus is that the bandwidth of the next-generation optical access network will be increased to

50 Gbps. How to simply and efficiently achieve that bandwidth upgrade has become a hot topic in PON research.

The IEEE was the first organization to start formulating the next-generation PON standard, which supports 25 Gbps downstream and 10 Gbps/25 Gbps upstream over a single fiber and is compatible with 10G EPON. To deliver 50 Gbps rates, it uses wavelength stacking and channel bonding technology to provide two 25 Gbps channels. The ITU-T/FSAN, after considering the needs of home, enterprise and mobile backhaul/fronthaul, established next-generation PON requirements with a focus on 50G PON providing a single-wavelength rate of 50 Gbps. In 2018, the ITU-T/FSAN started the standardization of single-wavelength 50G PON referred to as G. higher speed PON (G.hsp). The standard is expected to be released by the end of 2021.

50G PON is able to provide over 4-fold increase in bandwidth, better service support, and stronger network security compared to 10G GPON. It also should support the compatibility with the existing ODN.

Both the upstream and downstream wavelengths of 50G PON operate in the O band, making 50G PON unable to coexist with GPON and 10G GPON at the same time. 50G PON uses an LDPC FEC scheme. To better support low-latency applications, 50G PON introduces technologies like dedicated activation wavelength (DAW) and cooperative dynamic bandwidth allocation (CO-DBA). Table 1 shows a comparison of key performance metrics between 50G PON and 10G GPON.

10G GPON and 50G PON: Evolution and Coexistence

During network evolution, using the existing network resources to save upgrade and evolution costs has always been a priority for operators. In order to realize the smooth evolution from 10G GPON to 50G PON and meet the networking requirements of different services, 10G GPON and 50G PON will coexist for a

Item	50G PON	10G GPON
Line rate (downstream)	49.7664 Gbps	9.95328 Gbps
Line rate (upstream)	9.95328/12.4416/24.8832/ 49.7664 Gbps	2.48832/9.95328 Gbps
Line coding	NRZ	NRZ
FEC	LDPC (17280, 14592)	RS (248, 216)
Quiet window	Can be created on DAWs	Only created on service wavelengths
CO-DBA	Supported	Not supported
Maximum number of burst frames per T-CONT every 125 us	16	4
Compatibility with the existing ODN	10G GPON	GPON
Channel bonding	TC-layer channel bonding	Service-layer channel bonding
Slicing	Supported	Not supported

Table 1. Comparison of key performance metrics between 50G PON and 10G GPON.

certain period of time. A good coexistence scheme minimizes the equipment footprint, reduces the energy consumption of the optical access equipment, reuses the existing ODN, and reduces the network construction cost of the operator. Using the multi-mode optical transceiver modules in the OLT, such as the Combo PON module that supports both 50G PON and 10G GPON, has been regarded as an effective way so far.

The coexistence of 10G GPON and 50G PON should meet the following requirements: coexistence of 10G GPON and 50G PON over the same fiber, avoiding or minimizing service interruption on ONUs that are not upgraded, and supporting compatibility with the services of 10G GPON.

After discussions, the ITU-T has determined that 50G PON will not coexist with both GPON and 10G GPON at the same time. To enable coexistence, the evolution to 50G PON can be completed in two steps: first from GPON to 10G GPON and then from 10G GPON to 50G PON. This approach achieves continuous bandwidth upgrades while ensuring that the network evolution is smooth and cost-effective.

Key 50G PON Technologies

Wavelength Selection

Currently, 50G PON can only use a small portion of wavelengths in the O band, which are not enough. The ITU-T has decided on some wavelengths and is still discussing the other wavelengths.

Line Coding

The ITU-T had considered a number of line coding schemes for 50G PON, including PAM-4, duobinary modulation, and NRZ code. It ultimately decided to adopt NRZ code that has the highest signal receiving performance, because the PON system requires a very high optical power budget.

Line Rate

The ITU-T has made clear the rate requirement of 50G PON, and supports a combination of symmetric and asymmetric rates, with one downstream rate and four upstream rates available.

FEC

The increase in the line rate of 50G PON reduces receiver sensitivity. To reuse the considerable ODN resources, receiver performance has to be improved. To lower the specifications requirements for optical components, 50G PON uses the LDPC scheme for FEC.

Common Transmission Convergence

50G PON implements low latencies mainly through DAW, CO-DBA, and shortening the bandwidth allocation interval.

- **DAW:** A DAW can be a wavelength newly defined for 50G PON or one deployed for a PON system preceding 50G PON. It can be an independent upstream wavelength or a pair of upstream and downstream wavelengths. The DAW technology avoids opening a quiet window on the upstream wavelength, thereby eliminating the delay caused by the quiet window.
- **CO-DBA:** The OLT learns about the upstream service transmission requirement of the ONU through the upstream equipment, and then allocates bandwidth to the ONU in advance. This mechanism reduces as much as possible the time for which the service data is cached in the ONU.
- **Shortening the bandwidth allocation interval:** The interval between bandwidth allocations for the ONU is slashed, thus reducing the service data cache time in the ONU. Each T-CONT supports a maximum of 16 burst frames in a 125 us period.

PHY Components

The PHY components of 50G PON mainly include key optoelectronic devices such as optical transmitter modules, optical receiver modules, laser device drivers (LDDs), burst-mode TIAs, and clock-data recovery (CDR) chips. The OLT can use EML or integrated SOA-EML components as the transmitter module, and APD or integrated SOA-PIN components as the receiver module. The ONU differs from the OLT in that the ONU driver needs to support the burst function and that the ONU receiver does not require the burst-mode CDR feature. Experiments and simulations in the industry show that, by using a 50G EML transmitter and an APD receiver, 50G PON can attain a single-wavelength rate of 50 Gbps.

As the industry works on the standardization of 50G PON, some of its technical requirements and possible development directions need further research. One example is to provide exclusive bandwidth for operators or services. Another example is to address the latency and cost/performance requirements to meet the tight upstream optical power budget of 50G PON. It is estimated that 50G PON will be put into commercial use by about 2025. Before that time, 10G PON will be deployed on a large scale, laying a solid foundation for its smooth evolution to 50G PON.

As an active player in the industry, ZTE has submitted over 300 proposals in the PON field to standard organizations such as ITU-T SG15 Q2/FSAN, and holds key positions (e.g. editor) of many standards related to PON technologies. ZTE is now promoting the standardization of 50G PON and improvement of the relevant industry chain. In addition to making breakthroughs in the technologies for some key 50G PON components, ZTE has submitted more than 30 proposals on 50G PON, and those related to physical layer parameters, low latency, and FEC have been adopted by the standard organizations. ZTE TECHNOLOGIES

Evolution to Wi-Fi 6E and Wi-Fi 7

Zhang Zhigang, FN Product Planning Director, ZTE

Wi-Fi Proves Its Value Worldwide

After six iterations and especially evolution to Wi-Fi 4, Wi-Fi 5 and Wi-Fi 6, Wi-Fi technologies have been widely deployed across the globe. Wi-Fi 6 provides larger capacity and higher performance, reducing the pressure and urgency for operators to build expensive cellular networks. The complementarity between Wi-Fi 6 and 5G further improves wireless connectivity.

Wi-Fi 6E Addresses Wi-Fi Spectrum Shortage

The demand for Wi-Fi has been increasing steadily over the past 20 years. However, the amount of available unlicensed spectrum remained unchanged until 2020, resulting in a serious spectrum shortage. As a new unlicensed band, 6 GHz is an especially attractive spectrum option for Wi-Fi deployment. Wi-Fi 6E is Wi-Fi 6 extended to the 6 GHz band.

- **Contiguous spectrum:** Because the 6 GHz band is adjacent to existing 5 GHz spectrum, it can reduce the

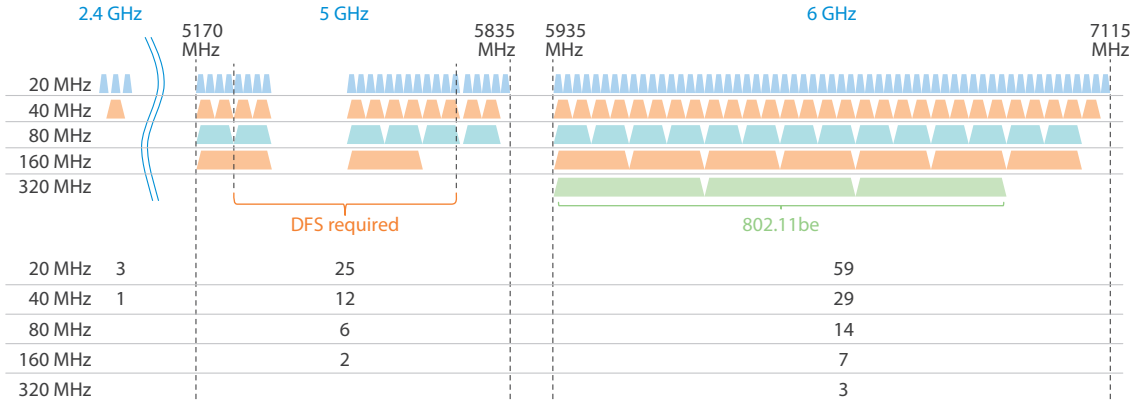


Fig. 1. The 6 GHz band available for unlicensed Wi-Fi use.

> As an important milestone in the development of next-generation Wi-Fi technologies, Wi-Fi 7 aims to provide extremely high throughput and support low-latency services.
>
> Zhang Zhigang

cost of adding 6 GHz capabilities to Wi-Fi devices that support the 5 GHz band. The propagation characteristics of 6 GHz signals are similar to those of 5 GHz signals. This makes it easier to upgrade Wi-Fi devices and enables the reuse of coverage maps and metrics of 5 GHz networks.

- **Wider bandwidth:** The 6 GHz band has 1200 MHz of contiguous spectrum and allows for wider bandwidth, thus meeting the requirements of high-throughput and low-latency services like HD video, AR/VR and telepresence.
- **Reduced interference:** In Wi-Fi applications, the 6 GHz band is relatively not congested because it is used only by Wi-Fi 6 devices. By shifting applications with high requirements for throughput and latency to the 6 GHz band, congestion at the 2.4 GHz and 5 GHz bands is relieved, thereby improving the overall capacity and performance of the Wi-Fi devices already deployed (Fig. 1).

Wi-Fi 6E allows Wi-Fi devices to run at the 6 GHz band so that they can deliver 10 Gbps rates, extremely low latency, and a larger capacity. Some issues concerning the adoption of the 6 GHz band still need to be sorted out, however. For example, the 2023 World Radiocommunication Conference (WRC-23) is set to discuss the licensing regime of the band. In addition to using the 6 GHz spectrum, Wi-Fi 6E still offers the features and capabilities mandated by the Wi-Fi Certified 6 program.

Wi-Fi 7 Focuses on Boosting Data Rates

Wi-Fi 6 was standardized by the IEEE 802.11ax high efficiency WLAN (HEW) study group with the main purpose of raising efficiency. The study group of Wi-Fi 7 is named IEEE 802.11be extremely high throughput (EHT). As the name indicates, a crucial objective of Wi-Fi 7 is to increase Wi-Fi rates. Video will constitute the bulk of traffic delivered via wireless local area networks (WLANs). New 4K and 8K videos require high uncompressed rates, and their throughput requirements are constantly evolving. High-throughput and low-latency new applications such as AR/VR, gaming, remote office, and cloud computing will also emerge in large numbers. The Wi-Fi 7 (802.11be) standard aims at:

- Configuring at least one mode of operation that supports a maximum throughput of at least 30 Gbps;
- Supporting the frequency bands between

1 GHz and 7.125 GHz (2.4 GHz, 5 GHz, and 6 GHz bands);

- Enabling downward compatibility with the 802.11a/b/g/n/ac/ax standards. Wi-Fi 7 defines at least one mode of operation capable of improved worst case latency and jitter.

The milestones of Wi-Fi 7 standardization is shown in Fig. 2. The standardization project was initiated in 2019 with the establishment of task group be (TGbe) and is intended to release the Wi-Fi 7 standard in 2024.

The main features of Wi-Fi 5, Wi-Fi 6 and Wi-Fi 7 are compared in Table 1.

Wi-Fi 7 (802.11be) has the following main candidate features:

- Supports a maximum of 16 spatial streams, doubles the total rate of Wi-Fi 6, and enhances the multiple-input multiple-output (MIMO) mechanism.
- Supports up to 320 MHz bandwidth, doubles the per-stream rate of Wi-Fi 6, and allows the aggregation of non-contiguous channels.
- Supports 4096 QAM, improves performance by 20% compared with 1024 QAM, and enhances the MIMO mechanism.
- Adopts multi-link operation (MLO) and multi-RU (via preamble puncturing) techniques, which allow link-layer aggregation and coordination of different bands and channels. Traffic steering and load balancing among multiple bands and channels, concurrent transmission through multiple bands and channels, and repeated transmission are performed to increase reliability.
- Supports multi-AP coordination, which employs methods, such as avoiding interference and collision between basic service sets (BSSs), having multiple APs send the same data frame, and collecting channel state information (CSI) of unassociated STAs, to significantly boost network performance in multi-AP environments. This technology is especially useful as a performance booster in homes and businesses where an increasing number of mesh APs are deployed.
- Uses enhanced link adaptation and transmission protocols, such as hybrid automatic repeat request (HARQ).
- Enhances the low-latency capability. To support real-time application (RTA), TGbe analyzed the main findings of the IEEE 802.1 time-sensitive networking (TSN) task group and discussed how to optimize technologies including enhanced distributed channel access (EDCA) and enhanced uplink OFDMA-based random access (UORA). Ongoing discussions conducted by TGbe cover the backoff procedure, access categories (ACs) and packet service policies.

As an important milestone in the development of next-generation Wi-Fi technologies, Wi-Fi 7 (802.11be) aims to provide extremely high throughput and support low-latency services. Its standardization is still at an early stage. Theoretically, high throughput and low

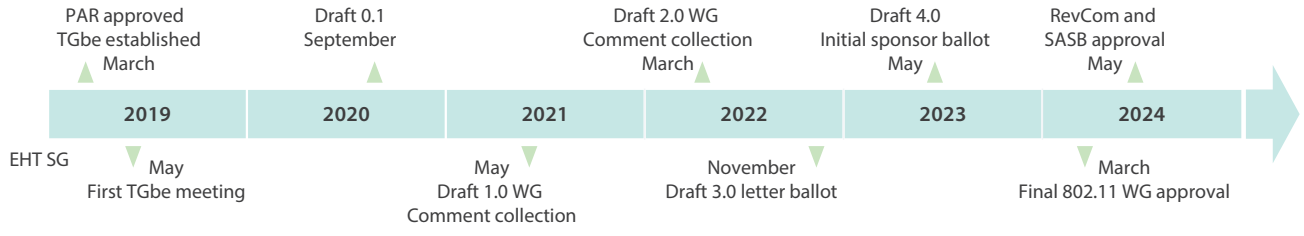


Fig. 2. The milestones of Wi-Fi 7 standardization.

Standard	802.11ac (Wi-Fi 5)	802.11ax (Wi-Fi 6)	802.11be (Wi-Fi 7)
Release time	2013	2020	2024
Operating band	5 GHz	2.4 GHz, 5 GHz, 6 GHz	2.4 GHz, 5 GHz, 6 GHz
Maximum transmission rate	1 Gbps	10 Gbps	46 Gbps
Transmission technology	MU-MIM, OFDM	MU-MIMO, OFDMA (single-STA, single-RU)	MU-MIMO, OFDMA (single-STA, multi-RU), Multi-AP, multi-link
Channel bandwidth	20/40/80/160/80+80 MHz	20/40/80/160/80+80 MHz	20/40/80/160/240/ 320/80+80/160+80/ 160+160 MHz
Number of antennas	8×8	8×8	16×16
Modulation	BPSK, QPSK, 16 QAM, 64 QAM, 256 QAM	BPSK, QPSK, 16 QAM, 64 QAM, 256 QAM, 1024 QAM	BPSK, QPSK, 16 QAM, 64 QAM, 256 QAM, 1024 QAM, 4096 QAM
Coding	Convolutional code, LDPC	Convolutional code, LDPC	Convolutional code, LDPC, others

Table 1. Comparison of main features of Wi-Fi 5, Wi-Fi 6 and Wi-Fi 7.©

latency can be realized through the EHT PHY specification, which features 4096 QAM, 320 MHz, 16×16 MU-MIMO, and the EHT preamble. In practice, however, due to the unlicensed spectrum, interference, and high overhead, EHT PHY alone cannot achieve significant throughput and latency gains for end users. This is why TGbe is also exploring other important innovations, such as enhanced EDCA, flexible OFDMA, multi-link operation, and reduced channel sounding. Additionally, TGbe is discussing advanced PHY techniques that can improve spectral efficiency, such as HARQ, non-orthogonal multiple access (NOMA), and full duplex (FD), as well as various multi-AP coordination methods. This represents another approach to reducing interference. While the former approach is to perform separate transmissions that are based on time, frequency, space or power, the new one is to conduct joint transmissions in a distributed large-scale antenna system. Although TGbe may delay releasing many advanced PHY and multi-AP coordination features of next-generation Wi-Fi standards, these features indicate the direction of development beyond Wi-Fi 7.

ZTE has actively participated in the formulation of the Wi-Fi 7 standard by providing theoretical support and engineering validation in areas including operation performance of OFDMA, RU allocation mechanisms, media access control (MAC) support for RU allocation, low-latency support in multi-link operation, channel access mechanisms, coordination among multi-link devices (MLDs), and low-latency statistic measurement and optimization.

Wi-Fi to Create More Value in the Future

As Wi-Fi advances, innovations and solutions will continue to emerge to deliver high-quality connectivity anywhere, anytime to meet user needs. The social and economic value of Wi-Fi will keep rising. ZTE TECHNOLOGIES

The World's Fiber Future is Here

Jeff Heynen

Vice President of Broadband Access and Home Networking at Dell'Oro Group

In the world of communications and networking, the year 2020 marked a turning point for communications service providers, as well as consumers and subscribers around the globe. 2020 was the year that fiber cemented itself as the preferred access technology of the future for a majority of operators. The catalyst for this strategic shift was the impact COVID-19 had on residential broadband network utilization rates, along with the dramatic increase in premium broadband subscribers around the world.

According to many operators around the world with cable, DSL, and fiber broadband networks, upstream peak traffic growth throughout 2020 increased over 50%, while downstream peak traffic growth increased 30%. In the early days of lockdown, operators reported staggering 125% increases in peak upstream and downstream growth, which ultimately leveled off as software adjustments were made to network platforms, and new capacity in the form of line cards and upgraded CPE was added.

Although the world is gradually returning to normal, with teleworkers moving slowly back into their offices, there is simply no turning back now for broadband subscribers who either upgraded or switched to FTTH services. The near-symmetric speeds pushing 1 Gbps and beyond, the resulting elimination of buffering for streaming video, and the near-flawless performance of online and VR gaming, and video conference calls are more than enough to warrant holding on to their premium broadband.

As a result, we expect global FTTH subscribers to continue to expand on a global basis, with the highest growth (by percentage) to come from Europe, North America, and CALA, where fiber penetration rates remain below 50% for most countries in each region (Fig. 1).

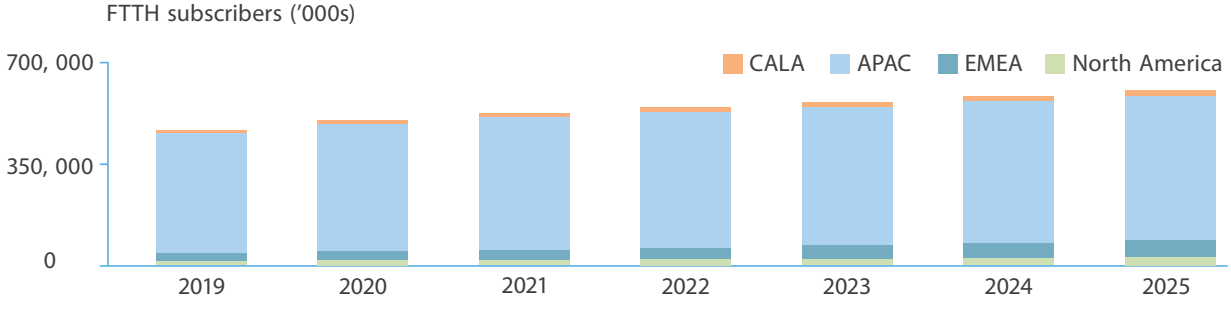
Fiber Expansion Will Rely on a Wide Range of Technologies

The fiber expansion in 2020, which saw total spending on PON equipment jump 8% (Fig. 2), involved multiple technologies—from 1G EPON and 2.5G GPON to XG-PON

and XGS-PON. While the clear trend among operators is to expand their fiber services using 10G technologies, there are still hundreds of operators who will continue to rely on 2.5G GPON as the workhorse for their fiber networks for years to come.

The diversity in PON technology choices specifically reflects the fact that fiber networks are no longer being considered for just residential applications. Instead, the same fiber networks that deliver residential services are now also being used for business and wholesale access. Additionally, the global expansion of 5G networks and continued small cell densification are opening up opportunities for 10G technologies to be used in both mid-haul and backhaul applications.

For operators considering a fiber deployment or network expansion, the key decision points used to be "how many homes can I pass?" and "what percentage of those homes will become subscribers?" While those remain critical metrics, the ROI equation for fiber networks has become increasingly easier



Source: Dell'Oro Group

Fig. 1. Global FTTH subscribers by region.

given the additional revenue potential from wholesale and business services, in addition to providing mid-haul and backhaul functions for a growing network of 5G small cells. The application and technology roadmap for PON networks and technologies has become much clearer, making it much easier for operators to justify the initial construction and buildout costs of their fiber networks.

Adding more incentive for operators to expand their PON networks has been the growing commercial availability of combo cards and optics, which can support 2.5G GPON, XG-PON, or XGS-PON from the same platform. These multi-technology options allow operators with existing PON deployments to begin the process of upgrading their networks to 10G on a gradual basis, without having to do a flash cut of entire service areas. Instead, operators can continue to deliver 2.5G GPON services to the bulk of their residential subscribers, while allocating XGS-PON wavelengths to business or high-end residential subscribers. Operators can then spread out the costs of more expensive 10G ONTs across a longer period of time.

More importantly, combo cards and optics don't force operators to change any aspects of their existing optical distribution network (ODN), allowing them to continue amortizing those initial construction and equipment costs over a longer period of time. From feeder and distribution cables to ducts, poles, and splitters, the co-existence of multiple PON technologies and re-use of the existing ODN is critical for operators around the world.

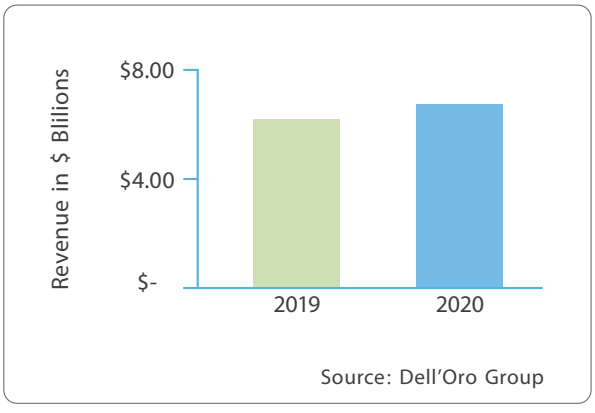


Fig. 2. Global PON equipment revenue.

Ensuring Fiber Experience in the Home, not Just to the Home

With more operators spending the time and money to roll out or expand their fiber networks and with competitive threats from other broadband providers not slowing down, operators are increasingly pushing fiber inside homes, not just to the front door. In cases where it is not feasible to run fiber throughout the home, operators are moving quickly to provide residential gateways that support WiFi 6 speeds and services and complementing those with additional mesh satellites when homes have WiFi dead spots.

By extending service into homes, operators can now remotely monitor the performance of in-home WiFi networks while also offering subscribers additional services, such as parental controls, bandwidth-on-demand, as well as bandwidth boosts by device or by application. As more IoT devices and sensors are introduced in homes, the combination of gateway software platforms, such as OpenWRT, prpl, EasyMesh, and RDK-B plus WiFi 6 gives operators an advanced set of features and options to package for their subscribers so that they can better manage and monitor the performance of all these new IoT devices.

Specifically in the case of providing bandwidth-on-demand services, fiber networks provide the most flexibility for scaling upstream and downstream bandwidth based on individual subscriber requests. Cable networks are limited in how much upstream bandwidth can be allocated, unless they move to a full-duplex architecture, which is both costly and time-consuming.

In a growing number of cases, operators are eliminating any concerns they might have about in-home wiring and WiFi performance by offering to extend fiber directly to multiple locations within the home. China Telecom and China Mobile are expanding their in-home ONT projects to ensure near-gigabit speeds to all devices in the home. Though not all fiber providers around the world will follow these operators' lead due to higher labor costs, there are more operators considering the move as it truly future-proofs their networks and services and further cements their relationship with subscribers.

Sharing Best Practices to Move the Industry Forward

Over the last decade, operators have been benefitting from the lessons they've learned during their own fiber deployments and sharing those lessons with the industry. From securing right-of-way and building access to micro-trenching techniques to the optimal deployment of ODN infrastructure and components, the cost and complexity of deploying fiber networks have been significantly reduced. The sharing of best practices among operators has resulted in the identification of consistent problem areas that can add unnecessary costs or delays to a fiber network rollout. For example, a major portion of the time and cost of last-drop fiber deployments is around digging trenches and burying new ducts within those trenches. Over time, operators have learned to identify ducts or trenches that are already in place so they can re-use that existing infrastructure rather than starting from scratch. This situation is becoming more common as multiple operators roll out fiber to new small cell locations, business parks, or extend feeder fibers into neighborhoods for cable node splits.

Additionally, reducing labor costs and rollout delays by using pre-connectorized fiber is an industry best practice that has evolved over time. Using pre-connectorized fiber eliminates the need for on-site splicing and also expands the labor pool of technicians who can complete a subscriber connection.

As an increasing number of operators deploy fiber in different countries with various topography, regulatory restrictions, and labor pools, the industry as a whole will benefit, further providing operators with more knowledge and more incentive to take the plunge and deploy their own fiber networks.

Fiber Everywhere

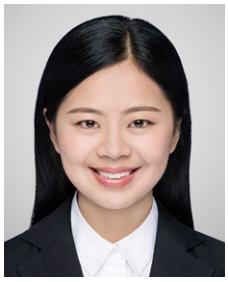
The global trend toward the deployment and expansion of fiber networks has never been clearer. What began in a handful of countries just a decade ago has proliferated to hundreds of countries and thousands of network operators globally. Fueled by new applications, new subscriber requirements, and new competition, operators clearly see their networks of today and tomorrow relying on fiber. The road map for fiber technologies and use cases continues to expand, along with the knowledge and implementation of best practices. Those two trends alone will continue to provide operators with strong incentives to deploy fiber and future-proof their networks for decades to come.

Finally, network equipment vendors are expanding their product and service portfolios to become more comprehensive partners to fiber providers. From in-home networking equipment to ODN infrastructure and central office equipment, these suppliers are adding network design and consulting capabilities to help their service provider customers reduce the cost of deploying fiber networks and speed their time to market. ZTE TECHNOLOGIES

Transforming MSOs into Full-Fiber Era

Sun Jin

FN Product Planning Manager, ZTE



Mao Yuting

FN Product Planning Director, ZTE

Video services such as IPTV/OTT, livestreaming and online education have become basic services in recent years. Some new services like virtual reality/augmented reality (VR/AR), cloud gaming, and cloud service have also witnessed considerable development, posing higher bandwidth requirements for networks. Since a VR channel consumes around 150–300 Mbps of bandwidth, the network needs to provide at least 500 Mbps of bandwidth. Moreover, the COVID pandemic has brought drastic changes to people's lives and spurred a surge in bandwidth demand. As people seek to enjoy services like online education, teleworking and home entertainment, high bandwidth in the home will stay on their list of needs. Both the rapid growth of video services and the pandemic-induced change in user behavior have prompted telecom operators to upgrade their networks to gigabit speeds. Under this situation, multi-service operators (MSOs) are facing increasingly serious challenges.

First, the bandwidth offered by cable networks is insufficient, and the roadmap of data over cable service interface specification (DOCSIS) is unclear. Due to the limitations of transmission media and the inadequacy of shared spectrum resources, cable networks have limited room for bandwidth improvement, and the broadband services they deliver are asymmetric. In the future, the insufficiency of upstream bandwidth resources will become ever more prominent. Moreover, the evolution path of DOCSIS is less clear than that of passive optical network (PON), and DOCSIS obviously lags behind PON in commercial deployment under the same bandwidth conditions. For example, the 10-gigabit-capable symmetric passive optical network (XGS-PON) technology has been commercially deployed on a large scale, while the similar DOCSIS 4.0 standard was officially released in March 2020 and has recorded just a few deployments.

Second, MSOs are confronted with the aging of coaxial cables. As the transmission medium of cable networks, coaxial cables usually have a service life of only 30 years, and their aging will affect bandwidth provision and service quality.

Third, MSOs have to deal with the pressure from telecom operators and OTT providers. Because of their network architecture and technical foundation, cable networks cannot meet diverse and flexible user requirements for ultra high definition (UHD) video services such as 4K,

8K and VR. The cable TV (CATV) service, which has poor interactivity, is facing pressure from IP-based streaming services. As IPTV is breaking the monopoly of cable service and OTT is leading the trend of service development, the traditional video service of MSOs is under intense competitive pressure.

Fourth, cable networks incur high operation and maintenance (O&M) costs and have a closed ecosystem. A cable network contains a large number of active devices. Because the devices have to be powered and maintained, they push up the operational expenditure (OPEX) for the MSO as time goes by. Furthermore, the cable modem termination system (CMTS) industry chain is controlled by a handful of manufacturers, resulting in high equipment costs.

Fiber Transformation: A Clear Trend for MSOs

In contrast to the sluggish growth of coaxial networks, optical networks are developing explosively. Fiber-to-the-anything (FTTx) networks represented by PON have been massively deployed worldwide over the past decade. By the end of 2020, there were already more than 700 million fiber-to-the-home (FTTH) users across the world, accounting for nearly 60% of the fixed broadband (FBB) customer base.

Many countries have made optical network construction a priority of their ultra-broadband initiatives. The British government plans to achieve national FTTH coverage in 2033. The ultra-broadband initiative of Italy explicitly states that optical networks are the strategic solution for realizing 100 Mbps connections. The recently unveiled Digital Europe programme designates fiber infrastructure as a funding priority of the European Union (EU) post-pandemic in a bid to advance the digital transformation of the continent. These national and regional policies are expected to create tremendous opportunities for MSOs to carry out fiber transformation.

Some leading MSOs have started FTTx deployments and operations, with more MSOs projected to get in on the act over time.

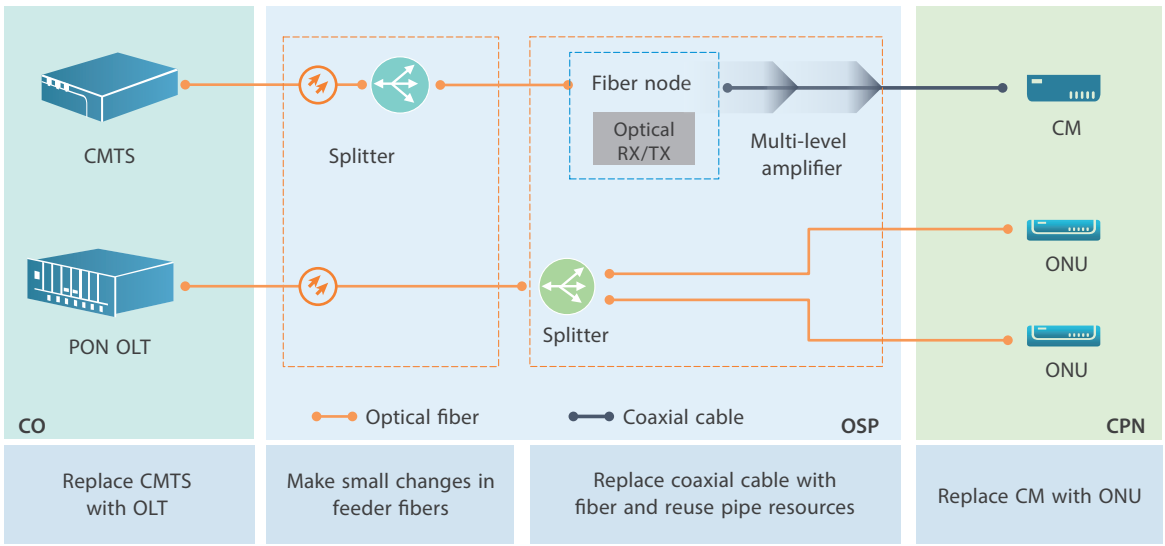


Fig. 1. Fiber transformation in a brownfield deployment.

Accelerating Fiber Transformation to Save TCO

Whether used in a brownfield or greenfield deployment, PON substantially cuts the five-year total cost of ownership (TCO) of the network compared to DOCSIS.

- **Brownfield deployment:** MSOs can fully reuse existing resources including pipes and fibers to reduce the engineering workload. They can replace the coaxial cables with fibers in the user section, the CMTS with an optical line terminal (OLT) at the central office (CO), and the cable modems (CMs) with optical network units (ONUs) at the customer premises network (CPN) side (Fig. 1). After the upgrade, active components such as amplifiers are no longer needed, which effectively simplifies the network architecture and alleviates the O&M pressure.
- **Greenfield deployment:** The FTTH network features a simple architecture and uses a point to multipoint (P2MP) topology, thereby significantly saving feeder fibers and slashing network construction costs. Additionally, the FTTH network supports smooth evolution and can protect operators' initial investments.

Helping MSOs with End-to-End Fiber Transformation

ZTE has been working in the optical access field for over 20 years. Committed to bandwidth acceleration and application innovation, ZTE continues to lead the development and commercialization of optical access technologies. Its leading end-to-end optical access products and solutions help operators deploy premium FTTx networks efficiently and cost-effectively. In the optical access space, ZTE has served in excess of 270 operators in over 100 countries, ranking second globally for shipments.

To enable brownfield deployments, ZTE provides industry-leading optical access products and solutions to help MSOs conduct fiber transformation end-to-end from the CO to the optical distribution network (ODN) and to the home (Fig. 2).

At the CO

ZTE offers TITAN, a future-proof flagship optical access platform that

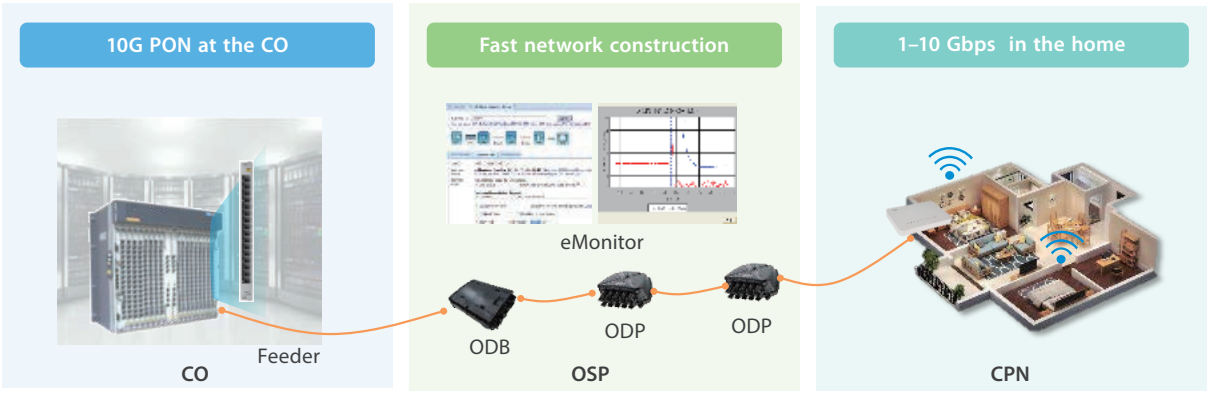


Fig. 2. End-to-end FTTH solution for fiber transformation.

adopts a fully distributed high-end router architecture and has the industry's highest slot bandwidth and largest switching capacity. By supporting the three generations of PON technologies (GPON/10G PON/50G PON) on one platform and the two technical standards (GPON/10G PON) on one card, TITAN enables smooth evolution and protects operator investments.

ZTE's innovative wavelength-division dual-channel Combo PON solution integrates three PON technologies into one card. Compared with the traditional way of using an external optical multiplexer (also called a WDM1r) to upgrade the network, the Combo PON solution saves equipment room space by 60% and does not require extra equipment or change the existing ODN and optical power budget. One Combo PON module can simultaneously connect to three types of ONUs. As the network evolves, the OLT does not have to be changed and only ONUs are upgraded as needed. Thanks to these advantages, the Combo PON solution is recognized by the industry as the best choice for smooth evolution to 10G PON.

In the Home

ZTE's mesh Wi-Fi networking solution enables seamless coverage for home networks. The solution provides 1+N multi-access point (AP) networking and supports self-healing to enhance network robustness. Users can enjoy wireless connectivity at speeds from 100 Mbps to 1 Gbps anytime and anywhere in the home. Ten-millisecond level smart roaming meets the latency requirements of video and online gaming, ensuring uninterrupted services while the user is moving and hence markedly improving user experience. The solution supports flexible O&M through the TR-069 protocol, a smartphone app, or a local Web GUI.

ZTE offers a series of EasyMesh-certified customer premises equipment (CPE) that can network with CPEs of other vendors on a plug-and-play basis.

In the Outside Plant

ZTE provides a pre-connectorized ODN solution that includes a family of pre-connectorized boxes for indoor and outdoor optical nodes as well as prefabricated optical cables. In replacement of traditional complicated fiber fusion splicing, the innovative connection of pre-fabricated optical cables makes fiber splicing easier and improves construction efficiency. This solution also boasts the industry's first pre-connectorized connectors that support blind insertion and self-lock. Thanks to its modular design, the solution offers all-weather deployment and ensures easier operations and more flexible networking.

ZTE has more than 15 years of expertise in the ODN sector and rich experience in turnkey project implementation. It has deployed ODNs in 50-plus countries and regions, with the total home pass (HP) exceeding 20 million.

ZTE's fiber transformation solutions have been commercially deployed by multiple MSOs to assist them in getting a head start amid a wave of fiber-based network modernizations. In the optical access area, ZTE will continue to bolster foundational capabilities, focus on customer requirements and help operators build a competitive edge to achieve business success. ZTE TECHNOLOGIES

Pre-connectorized ODN Solution Accelerates Fiber Transformation

Luan Tian

FN Product Planning Director, ZTE

The emergence of high-bandwidth services such as 4K/8K video, livestreaming, telecommuting, and online education in recent years is changing people's way of life and stimulating the growth of bandwidth demand. Fiber-to-the-home (FTTH) has become the most mainstream broadband access technology, with huge amounts of fiber deployed worldwide every year. Compared with copper networks, fiber networks feature higher bandwidth, more stable transmission, and lower operation and maintenance (O&M) costs. When building new access networks, fiber is the first choice. For copper networks already deployed, operators have to find a way to carry out fiber transformation efficiently and cost-effectively.

Fiber Slicing Poses Challenges to FTTH Deployment

A common problem faced by operators in an FTTH deployment is that the optical distribution network (ODN) has a long construction period, causes great engineering difficulties, and incurs a high cost. Specifically, ODN accounts for at least 70% of FTTH construction costs and more than 90% of its deployment time. In terms of both efficiency and cost, ODN is the key to FTTH deployment.

ODN construction involves a lot of fiber splicing, which requires trained technicians, specialized equipment, and a stable operating environment. The efficiency and quality of fiber splicing is closely related to the skills of the technicians. In regions with high labor costs and for operators lacking trained technicians, fiber splicing presents big challenges to FTTH deployment and therefore hinders operators' efforts in fiber transformation.

Pre-connectorization Solves the Problem of Fiber Splicing

ZTE has launched its pre-connectorized ODN solution to enable efficient and low-cost construction of fiber networks. As part of ZTE's Light ODN solution, the pre-connectorized CDN solution is centered on replacing the traditional complicated fiber splicing operations with pre-connectorized adapters and connectors to make construction more efficient and cost-effective. The pre-connectorized CDN solution includes a series of indoor and outdoor pre-connectorized optical fiber distribution boxes (ODBs) as well as prefabricated optical cables. Based on the traditional ODB, the pre-connectorized ODB adds pre-connectorized adapters on its outside. The prefabricated optical cable is made by adding pre-connectorized connectors to a traditional optical cable. With the pre-connectorized ODB and prefabricated optical cable, technicians do not have to perform splicing operations when connecting fibers. They only need to insert a connector of the cable into an adapter of the ODB.

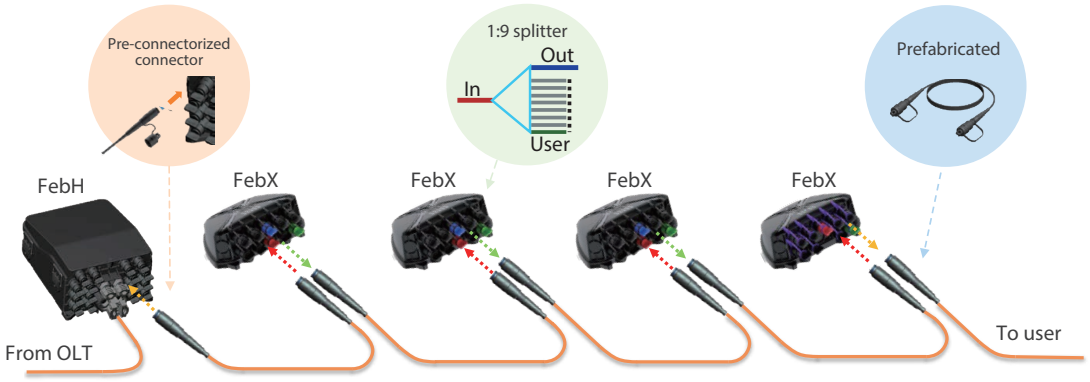


Fig. 1. ZTE's pre-connectorized ODN solution.

Pre-connectorization Helps Operators Build Networks Efficiently

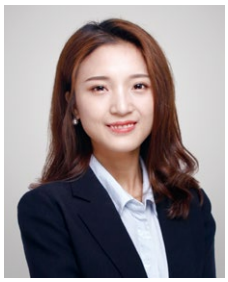
ZTE's pre-connectorized ODN solution (Fig. 1) features plug and play, simplified construction, flexible deployment, and easy O&M to assist operators in building FTTH networks efficiently.

- **Simplified engineering to save construction time:** The pre-connectorized ODN solution does not require trained splicing technicians or specialized splicing equipment. Fiber connection is simple plug-and-play and does not involve any splicing throughout the process, thereby cutting construction time by at least 50% and boosting overall deployment efficiency by 30% at a minimum.
- **"All-weather" products to achieve flexible deployment:** Drawing on its years of experience in fiber network construction, ZTE has developed a full range of indoor and outdoor pre-connectorized products that cover different scenarios of fiber networks. The products can be flexibly selected to implement optimum coverage in different scenarios. In outdoor settings, one pre-connectorized product supports multiple installation modes including overhead, pole-mounted, wall-mounted, and buried deployment. The pre-connectorized connectors have the IP68-rated water and dust resistance to ensure the reliability of fiber connections in severe weather conditions.
- **Modular design to facilitate O&M:** Every ODB is designed as an integrated whole with splitters pre-installed inside. The ODB can be deployed, operated and maintained without being opened on-site, thus improving its reliability and reducing O&M difficulty.
- **Industry's first connector that supports blind mating and self-locking:** ZTE's pre-connectorized connector and adapter use a unique mechanical design to enable blind mating. Technicians do not have to visually observe and match adapters and connectors. The connector is automatically guided to and aligned with the adapter to complete the mating operation. This mechanism decreases operating difficulty, increases insertion efficiency by 80%, and prevents the connector from being damaged by misaligned insertion. After the connector is inserted, the lock on the connector automatically rotates to fasten the connector to the adapter. This simplifies the operating procedure and avoids the connector falling off during construction.

ZTE's pre-connectorized ODN solution, which won a Lightwave Innovation Award in March 2021, has gained close attention and widespread recognition from the industry. The solution has been deployed on a large scale in many countries and regions, including in Europe, South America, and Southeast Asia. It has helped operators build networks in an efficient, low-cost manner and has greatly accelerated their fiber transformation. ZTE TECHNOLOGIES

10G PON & Wi-Fi 6:

Best Technology Mix for Gigabit Access



Han Xiaoyu

Wireline Products
Planning Director, ZTE

Demand for high bandwidth has soared as new services continuously emerge. The COVID-19 pandemic has further accelerated this demand, turning the home into a super information center for entertainment, learning or work. New interactive applications present many challenges for home broadband, such as video stuttering, frame loss, and audio-visual asynchrony during live streaming, online classes, and video conferences, making 100 Mbps connections increasingly inadequate. It has become urgent for operators to evolve towards gigabit access and make breakthroughs in terms of latency, packet loss, and the number of connections. A study shows that 32% of the customers would leave their beloved brands after just one bad experience, and customers would pay up to a 16% price premium for a good experience. Gigabit home broadband will help full-service operators boost user stickiness, gain competitive advantages, and raise average revenue per user (ARPU).

Gigabit broadband will be the cornerstone of an increasingly digitalized world. Governments across the world have successively launched gigabit initiatives and incorporated gigabit optical access networks into their strategies. As a leader in gigabit construction, China has built the world's largest gigabit network under the “dual gigabit", “triple gigabit”, and “full gigabit” plans. Based on EU’s vision for European Gigabit society, Germany has released its Gigabit Germany initiative, which aims to deploy gigabit networks by the end of 2025. Countries such as the UK and South Korea have also made similar plans. It can be seen that gigabit access has become an inevitable trend in response to enable service expansion, business development and national strategies.

On the network side, 10 Gbps connections should be available. Take VR as an example. The bandwidth of a single-channel VR service is 150–300 Mbps. More bandwidth will be needed with the introduction of new VASs like gaming, smart home IPTV and online education. It is clear that GPON access networks cannot accommodate gigabit services at scale and need to be upgraded to 10G PON. The 10G PON industry chain is now fully mature, supporting large-scale deployment.
On the other hand, Wi-Fi carries 90% of Internet traffic in a household. Research by an operator indicates that 53% of the complaints it received are related to home network issues, making Wi-Fi quality

critical to guaranteeing user satisfaction. To let users enjoy a true gigabit experience, operators need to further improve the quality of home networks and eliminate the bandwidth bottleneck. Some households using FTTH service fail to get gigabit broadband as a result of the low performance of their home gateways or the high attenuation of Wi-Fi signals caused by the building structures. In addition, with the emergence of new home services, home networks also need to have high bandwidth, low latency, and low jitter. Compared with Wi-Fi 5, Wi-Fi 6 has such characteristics as gigabit access, low latency, and massive connections, making it an important technology for gigabit broadband.

Operators can roll out gigabit networks in stages according to their network plans. Some operators may deploy 10G PON technology first to make their networks gigabit-capable and provide Wi-Fi 6 CPEs on demand to deliver a true end-to-end gigabit experience to users. Some operators may offer gigabit bandwidth over their existing GPON networks while deploying Wi-Fi 6 CPEs on the user side to boost network coverage and enhance user experience at their early stage of gigabit deployment, and gradually upgrade their networks to 10G PON as the gigabit user base expands. Therefore, 10G PON & Wi-Fi 6 is the best technology mix to achieve end-to-end true gigabit access. It can be used to build a gigabit optical access network, delivering gigabit speeds not only to the doorstep but also to every room. ZTE's 10G PON & Wi-Fi 6 solution (Fig. 1) employs innovative technologies and advanced products to help operators build real gigabit optical access networks and stand out in the gigabit era.

Efficient Network Construction

For 10G PON construction, the first

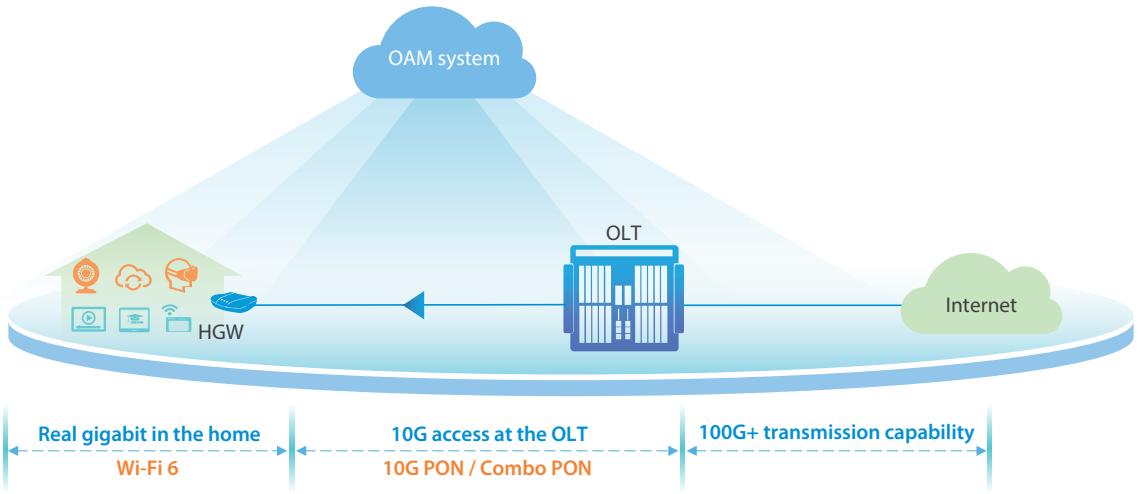


Fig. 1. ZTE 10G PON & Wi-Fi 6 solution.

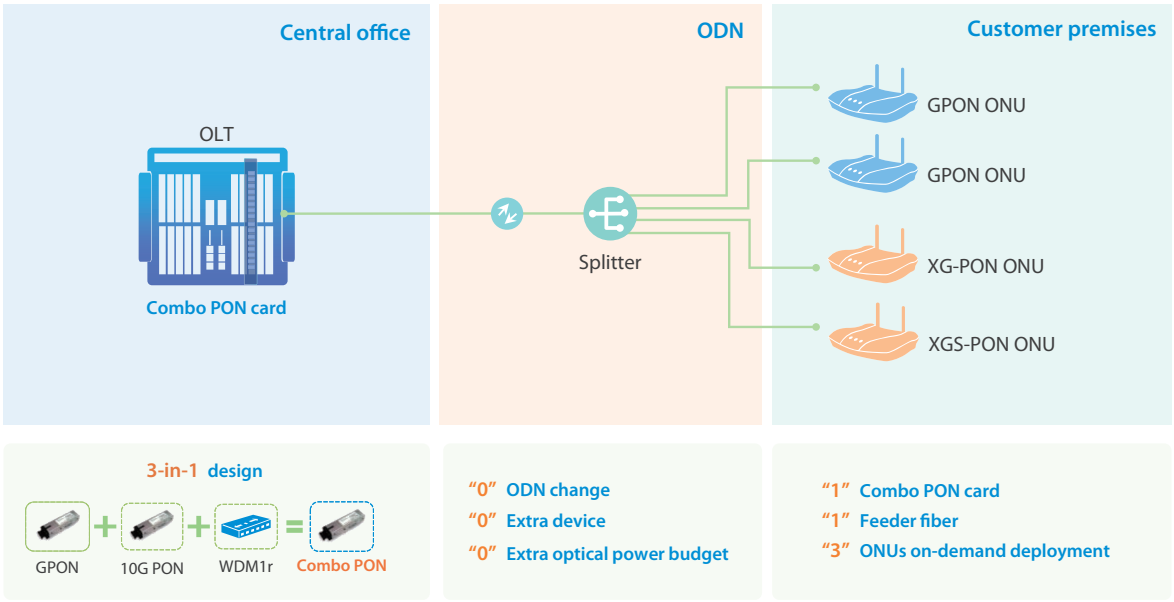


Fig. 2. ZTE Combo PON solution for smooth evolution to 10G PON.

issue to be addressed is how to upgrade the network cost-effectively and smoothly. A traditional upgrade involves adding 10G PON cards or an OLT as well as an external multiplexing unit, and both the optical distribution network (ODN) and fiber connections need to be modernized. ZTE's industry-first Combo PON solution (Fig. 2) uses a 3-in-1 design to integrate a GPON optical module, a 10G PON optical module, and an optical multiplexer (called WDM1r) into a Combo PON optical module. This solution allows operators to simply replace GPON cards with Combo PON cards without adding extra equipment room space or changing the existing ODN. Depending on their network and service conditions, they can deploy either GPON ONUs or 10G PON ONUs. This approach allows for one-off deployment of the Combo PON cards and on-demand evolution of the ONUs, thus saving network construction investments. To date, the Combo PON solution has been tested, trialed and deployed by more than 30 operators around the world, and has become the first choice for Chinese operators to build their 10G PON networks. ZTE also offers a lightweight tool to facilitate the migration from GPON to 10G PON. With a click of a button, data configuration and switching will be completed, greatly improving the migration efficiency and accuracy.

A premium 10G PON network requires the support of a superior OLT platform. As an industry-leading flagship optical access platform, the ZTE TITAN OLT provides a solid foundation for the deployment of 10G PON networks and gigabit services.

- First, the TITAN enables large-scale 10G PON deployments. It uses 16-port high-density 10G PON cards, which translates into one large-capacity device providing up to 272 10G PON ports and connecting over 17,000 users of 4K video.

- Second, the TITAN has the industry's highest per-slot bandwidth and switching capacity and is capable of processing the massive traffic generated by gigabit access.
- Third, the TITAN adopts a fully distributed architecture to implement non-blocking forwarding of gigabit services. It contains ZTE's in-house 5-in-1 chips with built-in network processor (NP) functionality that can be flexibly programmed to accommodate the diverse scenarios and services of the gigabit era while reducing the equipment energy consumption.

True Gigabit Home Experience

ZTE leverages its key Wi-Fi 6 technologies and a family of Wi-Fi 6 products to deliver at-home gigabit experience.

- Extended range and dual-carrier modulation (ER+DCM) technologies are used to enhance remote coverage and eliminate indoor blind spots. A smart QoS mechanism is also introduced to slash latency by 70%, which ensures the user experience of latency-sensitive services like VR and gaming.
- ZTE's comprehensive customization capability enables operators to meet service requirements while reducing equipment costs and creating brand value.
- ZTE has in-house CPU chips for CPE products, and it works with mainstream chipmakers to provide a stable and reliable supply of CPEs for customers. With several self-owned factories and outsourced factories across the world, ZTE is able to guarantee prompt delivery.
- ZTE has submitted over 70 standard proposals and acts as the chair of the IEEE 802.11ax PHY Working Group to contribute to industry standardization.

ZTE's full range of Wi-Fi 6 products have been put into large-scale commercial use across countries such as Japan, Italy and China.

Premium Gigabit Networks

In an age when the experience of Internet users reigns supreme, operators are gradually shifting their focus from delivering a sufficient bandwidth to guaranteeing a satisfactory experience. To improve the gigabit service user experience, operators need to measure and manage the end user experience over their networks. ZTE utilizes a series of experience assurance solutions to guarantee the quality of gigabit networks. For home networks and associated devices, a cloud platform is used to perform management functions like topology visibility, fault reporting and remote upgrade. For optical access networks, an expert system is applied to analyze weak optical points and the resulting data is used to help operators optimize the points. For gigabit services, traffic data is collected in real time to provide the big data foundation for smart operation and maintenance (O&M), including fast fault location and network quality optimization.

Featuring high bandwidth, low latency, long lifespan, and high reliability, gigabit optical access networks will become a new basis of the digital economy. In addition to bringing gigabit to the home, gigabit optical access networks will enable the digital transformation of various industries, unlocking a new gigabit era. ZTE TECHNOLOGIES

Wi-Fi 6 Acceleration for Latency-Sensitive Services

Chen Daowei

Chief Engineer of FN Product Planning, ZTE

With the arrival of Wi-Fi 6 comes the massive deployment of gigabit fixed networks. The increasing adoption of gigabit broadband promotes rapid development of virtual reality (VR) service. The VR technology is characterized by immersion, interaction and conception, and its applications mainly include livestreaming and gaming. The development of the Internet and the widespread use of smartphones have generated an exponential growth in mobile gaming. There are currently more than 2.2 billion mobile gamers worldwide, with around 60% of the gaming devices connected to games via Wi-Fi. Peak latency between stations (STAs) and access points (APs) produces over 60% of game buffering. The recently emerging cloud VR games demand that home Wi-Fi networks provide high bandwidth and low latency.

Network Requirements of Latency-Sensitive Services

Multiplayer online battle arena (MOBA) is a genre of games that is currently in vogue. MOBA games generally require a latency of no greater than 50 ms, a bandwidth of 1 Mbps, and packet loss of less than 10^{-5}. VR games are rendered locally or in the cloud. For locally-rendered VR games, the network requirements are similar to those of MOBA. For cloud-rendered VR games, the network requirements are higher, with latency no longer than 15 ms, bandwidth at 260 Mbps, and packet loss smaller than 10^{-5}.

To accelerate MOBA and cloud VR games, they first have to be identified from the many services carried over the Internet pipeline. For MOBA games, the AP or gateway uses the game server domain name request originated by the gaming terminal to determine what type of game is being played, and utilizes the media access control (MAC) address of the terminal to decide what data traffic is generated by the game. Cloud VR games have high requirements for the entire network including the home, access, and upper-layer networks. The games are usually configured with dedicated channels that can be used to identify them.

Wi-Fi 6 Acceleration for MOBA Games

To enable low-latency, low-bandwidth MOBA games, ZTE has developed wireless routers that support MOBA game acceleration technologies. Lab test data shows that, under the same interference

environment, the acceleration technologies drastically reduce bi-directional latency from 12 ms to 5 ms.

- **Intelligently identifying MOBA games and changing their service priority:** The router uses deep packet inspection technology (DPI) or domain name requests to identify MOBA games, tags their service priority, and maps their traffic to the access category of voice (AC-VO) of Wi-Fi multimedia (WMM). This avoids MOBA games competing with other Internet services in the same channel for air time and helps gaming traffic better contend for air time.
- **Increasing the number of retransmissions to reduce packet loss:** Loss of MOBA game packets is not allowed. On the router, a high number of retransmissions can be configured for WMM AC-VO so that services like video and download do not cause Wi-Fi buffer overflows, thereby cutting the packet loss of MOBA games.
- **Disabling A-MSDU to boost transmission efficiency:** A Wi-Fi chip aggregates packets and then sends the aggregated packet to improve transmission efficiency. When a transmission error occurs, the aggregate MAC service data unit (A-MSDU) frame needs to retransmit the entire packet, which will greatly impair transmission efficiency in an interference-heavy environment. Disabling the A-MSDU function slashes the probability of aggregating the usually small packets of MOBA service. This not only decreases the retransmissions of the aggregate packet due to local packet errors, but also shrinks the waiting time experienced by the aggregate MOBA packet.
- **Lowering the modulation rate of gaming terminals to raise Wi-Fi coverage:** The router allows the initial modulation rate of game packets to be cut. For example, a modulation rate with 20 MHz bandwidth and a low modulation and coding scheme (MCS) can be configured to obtain a higher transmission gain to reduce packet errors and burst latencies. If the gaming terminal supports dual carrier modulation (DCM), which is a new feature of Wi-Fi 6, having DCM enabled on the router will further increase the transmission gain.

Wi-Fi 6 Acceleration for Cloud VR Games

To implement low-latency, high-bandwidth cloud VR games, ZTE has developed wireless routers that support cloud VR game acceleration technologies. Lab test data shows that, under the same interference environment, the acceleration technologies significantly decrease bi-directional latency from 21 ms to 7 ms.

- **Built-in mini-content distribution network (CDN):** To reduce latency, the home gateway or router can cache in advance the high-bitrate and large field-of-view (FOV) images of cloud VR games. When the user turns the VR headset, the cached images can be retrieved from the home gateway or router. This mechanism can reduce the latency between the home gateway or router and the cloud VR server by about 8 ms.
- **WMM priority mapping of cloud VR games:** Considering that cloud VR games are of high bandwidth and low latency, game traffic should be classified into control traffic and video traffic, and the two types of traffic should be tagged with different priorities at both the server and client. Control traffic takes up little bandwidth but does not

allow packet loss, while video traffic uses much bandwidth but tolerates a small amount of packet loss. Therefore, the router maps control traffic to the AC-VO and video traffic to the access category of video (AC-VI). In this way, control traffic can obtain Wi-Fi air time more easily, while video traffic can have more transmission opportunities (TXOPs) and more data can be sent.

- **Smart QoS based on Wi-Fi 6:** Wi-Fi 6 supports orthogonal frequency-division multiple access (OFDMA), enabling an AP to send data to multiple STAs simultaneously to enhance transmission efficiency at the air interface and lessen the packet latency. When one access category (AC) covers multiple STAs and services, priority scheduling can be performed to give a higher priority to VR game packets to ensure the quality of service (QoS) of VR games. When there are multiple ACs, different bandwidths can be allocated to them and the AP can schedule multiple ACs each time it sends data. Each time data is transmitted, VR game packets can be sent, thus increasing the throughput and reducing the packet latency of VR games.
- **Preamble puncturing based on Wi-Fi 6:** The preamble puncturing feature of Wi-Fi 6 allows the router to avoid an occupied bandwidth of 20 MHz in the middle of the channel. The router can switch among the 20, 40, 60, and 80 MHz bandwidths, which considerably improves switching flexibility. In addition, to reduce the interference conflict at the primary 20 MHz channel, a Wi-Fi 6 AP can obtain the channel information of the neighboring AP(s) through channel scanning and select a 20 MHz channel with the least interference as its primary channel. The router can use the dynamic frequency selection (DFS) function to notify the connected STA(s) to dynamically switch channels.
- **Intelligent packet discarding for video traffic of VR games:** Interference always exists at the Wi-Fi air interface, so low-probability packet loss is unavoidable. When packet loss occurs, some packets of the video traffic of VR games should be discarded. Different types of video frames are given different discarding priorities to ensure the transmission of key video frames and curtail the transmission of video frames that cannot be decoded. This technique improves video transmission efficiency and cuts video stuttering. When the video media server or CDN encodes videos to generate video packets, it tags different types of video frames with different differentiated services code point (DSCP) priorities. To distinguish different types of video frames, video transmission devices only need to identify their DSCP priority tags, thus accelerating the process of recognizing and discarding video packets.

ZTE employs a series of Wi-Fi 6 acceleration technologies to optimize latency-sensitive services such as MOBA games and cloud VR games. The acceleration technologies not only improve user experience of the games, but also provide comprehensive service assurance capabilities like easy installation and maintenance and efficient deployment, helping operators upgrade home networks from being bandwidth-centric to being experience-centric and make a strategic transformation. ZTE TECHNOLOGIES

Three-Rate Combo PON Enables Smooth Evolution to 10G GPON

Wang Guanqiao

FN Product Planning Manager, ZTE

High-bandwidth services have been undergoing explosive growth in recent years. Not only new home broadband services like 4K/8K TV, smart home, interactive video, cloud gaming, distance education, livestreaming, and home office are are gaining popularity, but emerging enterprise services such as cloudification, industrial Internet, and smart city/community/campus are also developing rapidly. The expansion of services calls for continuous bandwidth improvement, accelerating the upgrade of access technology from gigabit passive optical network (GPON) to 10G GPON.

Among the 10G GPON standards, 10-gigabit-capable passive optical network (XG-PON), which provides asymmetric rates that reach 10 Gbps downstream and 2.5 Gbps upstream, was the first to complete standardization. The high downstream rates delivered by XG-PON meets the bandwidth requirements of new services like big video, making the technology instantly win operator recognition and promptly start commercial deployment. To protect network investments, a way must be found for XG-PON to be compatible with existing GPON optical network units (ONUs) while allowing for smooth evolution and on-demand upgrades. ZTE did exactly that by launching the industry's first Combo PON solution to implement both XG-PON and GPON. This two-rate Combo PON solution has found popularity with operators by virtue of its good compatibility and great ease of use. It has become the primary solution for 10G GPON construction, and has been put into large-scale commercial use.

As more bandwidth-hungry services, especially new enterprise offerings, fast grow in popularity, the asymmetric XG-PON technology is increasingly not up to the task. Against this background, 10-gigabit-capable symmetric passive optical network (XGS-PON), which offers 10 Gbps bandwidth both upstream and downstream, is gradually becoming the technology of choice for 10G GPON deployment. Although the XGS-PON technology has matured, it still faces the problem of compatibility with a large number of in-service XG-PON and GPON ONUs when the network evolves to XGS-PON. To solve this problem, ZTE took the lead to release a three-rate Combo PON solution to combine XGS-PON and GPON and enable smooth evolution from GPON to XGS-PON.

Technical Implementation

The Combo PON solution integrating XGS-PON, XG-PON and GPON is a built-in optical multiplexing scheme that supports the coexistence of XGS-PON, XG-PON and GPON ONUs (Fig. 1). Also called "three-rate Combo PON", the solution is recognized in the industry as the best path for smooth upgrade from GPON to XGS-PON.

Because XGS-PON and GPON use different wavelengths, three-rate Combo PON multiplexes the two types of wavelengths in an optical module, thereby achieving separate transmission and reception of GPON and XGS-PON signals. The three-rate Combo PON optical module has an embedded multiplexer, called the WDM1r, to combine and divide the four upstream and downstream wavelengths needed by XGS-PON and GPON. XGS-PON uses the 1270 nm upstream wavelength and 1577 nm downstream wavelength, while GPON uses the 1310 nm upstream wavelength and 1490 nm downstream wavelength. The three-rate Combo PON optical module implements the transmission of four wavelengths over a single fiber. Meanwhile, because XGS-PON and XG-PON use the same wavelengths, XGS-PON is naturally compatible with XG-PON ONUs, which results in the coexistence of XGS-PON, XG-PON and GPON.

Leading the Trend in 10G GPON Deployment

Three-rate Combo PON can connect XGS-PON, XG-PON and GPON ONUs, allowing operators to meet the requirements of different customers. XGS-PON ONUs can offer dedicated-line access for enterprise users, XG-PON ONUs can provide gigabit access for home users, and GPON ONUs can deliver megabit access for home users.

Three-rate Combo PON has the following advantages over the PON solution using an external optical multiplexer:

- The optical distribution network (ODN) does not need to be adjusted, so deployment of the three-rate Combo PON solution is quite easy. The external multiplexer scheme means that a stand-alone multiplexer device needs to be installed and the ODN has to be greatly adjusted, which would cause considerable engineering difficulties. By contrast, because three-rate Combo PON

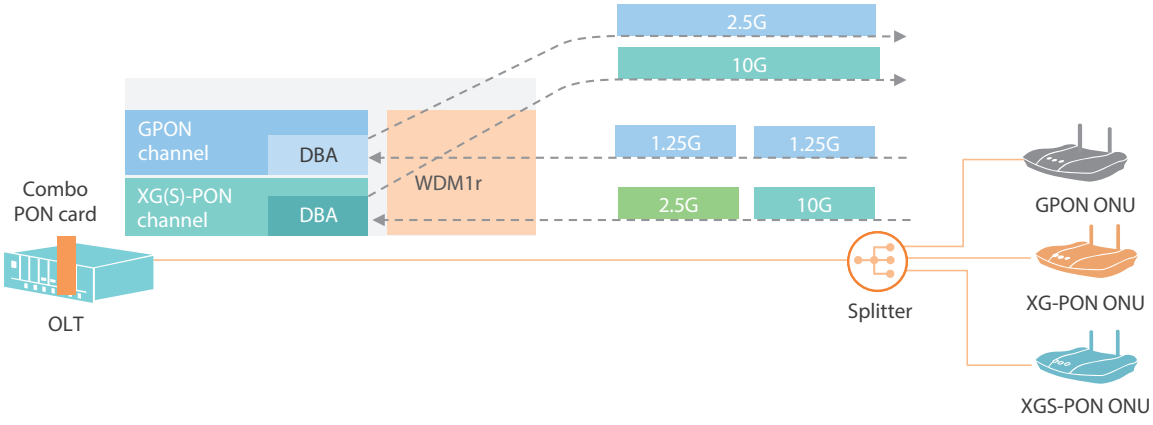


Fig. 1. Three-rate Combo PON solution.

employs an embedded multiplexer, compatibility with the in-service GPON ONUs does not require adjustments to the ODN, making the solution easy to deploy.

- No new insertion loss is introduced, thus completely solving the issue of optical power margin. An external multiplexer adds 1–1.5 dB insertion loss, which will 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 a same-class optical module, the solution does not change the optical power budget margin of the ODN.
- Equipment room space is saved and network O&M is simplified. Since the optical module of three-rate Combo PON integrates XGS-PON/XG-PON/GPON and WDM1r functions, it eliminates the need for additional equipment. As a result, no extra room space is required and O&M complexity is reduced.
- Interconnection between the element management system (EMS) and operation support system (OSS) is easy, the service provisioning process keeps unchanged, and service migration is fast. Three-rate Combo PON operates in wavelength division mode. The XG(S)-PON and GPON channels automatically match their ONU types, and can use the existing mode of interconnection between XGS-PON/GPON and the OSS. The service provisioning process is unchanged and services are easy to migrate.

In a new-build scenario, using the three-rate Combo PON solution can greatly reduce the initial costs and shorten the investment return period. At the initial stage when the bandwidth requirements are low, the operator can deploy GPON ONUs for common users and 10G GPON ONUs for high-end users. As services grow, the GPON ONUs may no longer meet user demand and the operator can replace them with 10G GPON ONUs. This approach of on-demand upgrading and smooth evolution can achieve a balance between investment and income within a short period of time.

The three-rate Combo PON solution has attracted high attention from top-tier operators in the world. ZTE is actively participating in the three-rate Combo PON tests and commercial trials with operators, leading the trend in 10G GPON deployment.

In China, 10G GPON deployment is in full swing. Recognizing that three-rate Combo PON enables smooth evolution and is compatible with a large number of existing GPON ONUs and XG-PON ONUs, the three major Chinese operators have started wide-scale deployment of the solution. Internationally, three-rate Combo PON has also been highly concerned by operators seeking to carry out bandwidth acceleration and fiber transformation. Incumbents, alternative carriers, and multiple system operators (MSOs) are all actively exploring the application of the solution by conducting tests and deployments. Based on the solution, ZTE has helped leading MSOs deploy their fiber-to-the-home (FTTH) networks.

ZTE's Combo PON solutions have been successfully installed in many countries to assist operators in building gigabit networks. With constant technology innovation, ZTE will continue to create high-quality products to help partners seize market opportunities and obtain competitive advantages. ZTE TECHNOLOGIES

Fixed Mobile Convergence in F5G Era

Li Yufeng

Chief Engineer of FN Product Planning, ZTE

Dual-Gigabit Network Drives Deep Integration of F5G and 5G

According to China's *Report on the Work of the Government 2021*, China will step up the development of 5G and gigabit optical networks and extend their applications to more scenarios. The importance of gigabit optical networks has attracted unprecedented attention. A dual-gigabit network usually combines gigabit optical network and 5G network to provide users with the gigabit access capability of both the fixed and mobile networks. The dual-gigabit network features ultra high bandwidth, super low latency, and higher reliability, with the component networks complementing each other. Such a network is an important part of the new full-fiber infrastructure and serves as the base that carries services. To implement the service deployment requirements of the government work report, the Ministry of Industry and Information Technology (MIIT) of China released the Action Plan for Coordinated Development of Dual-Gigabit Networks (2021-2023) to make the fixed and mobile networks promote each other in construction and integrate each other in services.

The research of fixed-mobile convergence (FMC) based on fifth generation fixed networks (F5G) and 5G mainly focuses on two areas:

- **Integration of F5G and 5G networks:** 5G macrocells or microcells are carried through the F5G infrastructure and undergo possible equipment integration. F5G continuously evolves to gain the capability to carry 5G base stations. China has basically achieved full fiber coverage. By the end of 2020, 880 million fiber-to-the-home/office (FTTH/O) ports had been deployed and 454 million optical access users had been signed up, accounting for 93.9% of China's fixed broadband user base. Fibers and ducts are valuable fixed broadband (FBB) infrastructure resources that lay a foundation for the construction of integrated access areas. 5G microcells are the base station variant most likely to be used in fixed access deployments. The bulk of demand for 5G microcells, including the indoor distribution and home installation flavors, is expected to still come from operators. FMC provides a solution for operators to substantially reduce their total cost of ownership (TCO).
- **Management of fixed and mobile terminals, and integration of service process and 5G core (5GC):** As dual-gigabit implementation advances, the public and campus networks both evolve towards a dual-gigabit architecture. While innovative services require significant changes in and are difficult to deploy on the public network, they are easier to trial and implement on the campus network where they can run on F5G and 5G. When used in the campus network, 5G has a number of advantages over Wi-Fi, including independent frequency bands, no interference, and low latency. Users demand the same superior experience whether they access

the network via 5G or F5G. Therefore, a major area of FMC research is on access-independent technology. Before dual-gigabit technology emerged, the Wi-Fi/wireline terminals and 5G terminals in a campus used to be authenticated by two separate systems. With dual-gigabit integration, all the terminals can be controlled and authenticated in a unified fashion to simplify management.

Integration of F5G and 5G Networks

Some operators that operate both fixed and mobile networks want to use the abundant fiber resources on their fiber-to-the-anything (FTTx) infrastructure to fronthaul or backhaul 5G macrocells. In some Chinese provinces or cities, radio access networks (RANs) have not been introduced but passive optical networks (PONs) have already been deployed. These markets present an opportunity for vendors to make breakthroughs and gain entry. In some European and American countries where installing new fibers is difficult, operators can use their existing FTTH resources to develop wireless services. They can utilize their market and technology advantages in both PON and RAN to raise the market access threshold and enhance customer stickiness.

To address the needs of the backhaul and fronthaul markets, ZTE has launched the Combo PON Plus solution (Fig. 1) that overlays point-to-point wavelength division multiplexing (P2P WDM) wavelengths on the feeder fiber of the optical distribution network (ODN) and uses them to carry 5G backhaul or fronthaul services. Thanks to the characteristics of WDM transmission, the solution has the following advantages:

- **High reliability:** Transmission goes through dedicated wavelengths and is not affected by what type of PON terminal is involved.
- **Low latency:** Transmissions are conducted in P2P mode.
- **High bandwidth:** Backhaul and fronthaul bandwidth is independent of PON bandwidth, leading to maximum single-wavelength rates of 10 Gbps currently and 25 Gbps in the future.

After rounds of discussion and revision conducted at end-2020 and in 2021, it was finally decided that Option 6 split microcells would target such scenarios as homes, small enterprises, and industrial parks. The microcells have strict latency requirements, so they must be carried using low-latency technology. Research shows that in the 4G era, around 4% of homes received poor wireless coverage because of weak signals. The problem is likely to get worse in the 5G age. In view of this, ZTE has collaborated with the Suzhou subsidiary of China Mobile to explore using the existing FTTx network to carry the

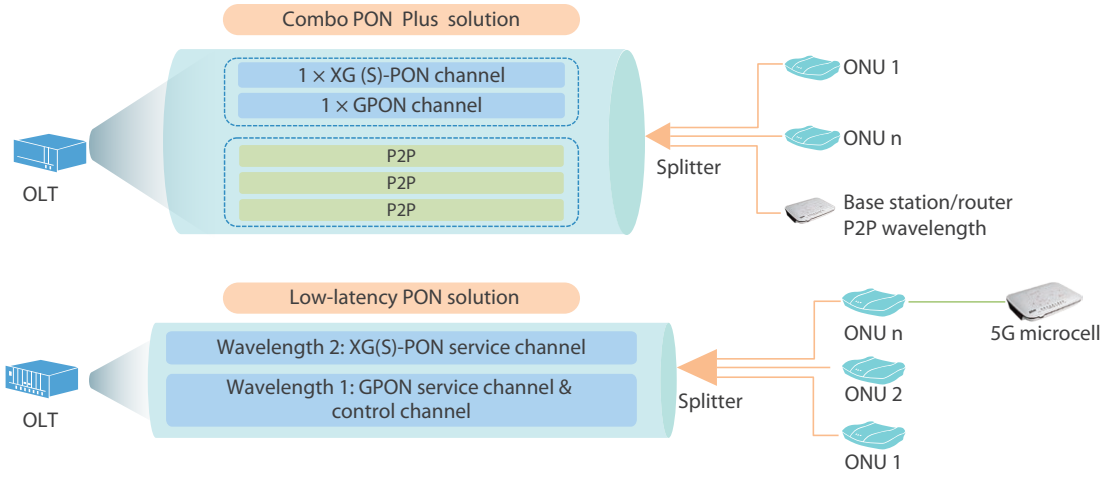


Fig. 1. ZTE's innovative Combo PON Plus solution and low-latency PON solution.

services of 4G/5G home microcells. The result of the live validation indicates that low-latency PON technology can reduce the upstream delay from millisecond to nanosecond levels.

ZTE has also carried out research on improving the current PON standards. For example, ZTE's low-latency PON technology is based on the TDM-PON standard but upgrades its dynamic bandwidth allocation (DBA) mechanism. The main implementation principle of the technology is that a third dedicated wavelength channel is used for 10G PON registration and ranging. On the forwarding plane with upstream DBA, the 10G PON channel increases the burst density of ONU scheduling per superframe, thus cutting the waiting time for data. In January 2020, ZTE and China Mobile Suzhou validated the low-latency PON technology and achieved the expected results.

Management of Fixed and Mobile Terminals, and Integration of Service Process and 5GC

5G wireless wireline convergence (5WWC) is based on the public network and has existed as a study item of the 3rd Generation Partnership Project (3GPP) for many years. Implementing 5WWC would require major network upgrades and incur other costs, so its advancement has been slow and operators have not yet presented any demand for its implementation. By contrast, in a campus network, such as one built for an industrial park, a school, or a government compound, the 5GC is deployed to the campus. This makes the campus network cheaper to deploy and more likely to get implemented compared with the public network.

The FMC requirements of a campus network include high broadband, mobile office, secure and reliable industrial control, and flexible industrial protocol adaptation. Terminals connected to the campus network may or may not be 5G capable. 5G terminals include automated guided vehicles (AGVs) and mobile production devices, while non-5G terminals include Wi-Fi-enabled PCs, Wi-Fi terminals, and wired desktop PCs. These campus terminals need to be managed, controlled, and authenticated in a unified fashion.

5G FMC offers a way to fulfil production and life needs in the campus. For example, unmanned goods transportation within a port, warehouse, or campus requires autonomous driving, which in turn calls for a high-bandwidth, high-reliability, and low-latency network to ensure that AGVs are automatically dispatched and controlled. The user plane function (UPF) is pushed closer to users, with the data plane terminated in the campus for classified processing or further AI analysis. The optical line terminal (OLT) contains multi-service edge computing (MEC)-capable blade servers, supports platform as a service (PaaS), and provides UPF services, thereby integrating the services and resources of fixed and mobile networks.

Outlook for FMC in F5G Era

A converged infrastructure that allows 5G microcells to be carried over an FTTx network is still under research and will be the main application of the convergence of physical fixed and mobile networks. Low-latency PON and P2P wavelength overlaying technologies can fully reuse the FTTx and PON network infrastructure, making it possible to deploy 5G microcells rapidly and at low cost. The 3GPP working group responsible for 5WWC standardization is still studying how to perform unified management and authentication in a public network with fixed-mobile convergence. Because its implementation requires coordination among operators, 5WWC is not expected to see fast progress on standardization and rollout. A campus network is basically a private network, and its construction involves minor changes to the existing network. As the rollout of 5G networks and passive optical local area networks (POLs) progresses, implementing integrated management and authentication on the basis of FMC may be the direction of research and implementation in the future. ZTE TECHNOLOGIES

5G Enabled Smart Manufacturing in Thailand

On May 21, ZTE partnered with Advanced Info Service Plc. (AIS), one of Thailand's top wireless carriers and Internet service providers, and Suranaree University of Technology (SUT), to demonstrate the first 5G smart factory in Thailand. Technologies involved include multiple advanced solutions such as 5G cloud machine vision, 5G industrial AGV, AR remote guidance, VR panoramic monitoring and unmanned inspection robots. The demonstration showed industrial entrepreneurs the possibility of deploying 5G in their production lines and turning their manufacturing plants into "smart factories".

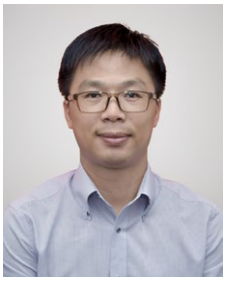
The Partnership

AIS is the largest operator in Thailand with 47% market share. ZTE and AIS has established partnership since 2015, and ZTE became one of the key wireless solution providers that year. After the release of 5G license in 2020 by Thailand's regulator, AIS became the first operator to offer 5G service in the country. Currently, AIS 5G service has been available in major cities of all 77 provinces of Thailand.

Another partner, SUT, is located in Nakhon Ratchasima, which is the gateway to other provinces of Northeastern Thailand. The province sits at an intersection between the Eastern Economic Corridor (EEC) and the Northeastern Economic Corridor (NEEC), and it hosts three major industrial estates. Owing to this advantageous location, SUT has been serving the needs of the industrial sector with numerous curricula relating to digital technology such as AI, cloud, IoT, VR and AR. The university also offers training in the scope of 5G technology to businesses. The partnership with ZTE and AIS is expected to provide SUT with equipment that enables the demonstration of a variety of use cases for 5G. Industrial entrepreneurs would have the opportunity to exploit 5G technology for efficiency improvement at their plants by

Lu Yeming

RAN Product Director, ZTE



Chen Yanfei

Operator Integrated Solution Manager, ZTE

observing use cases at the university and then determining how to best implement the technology in their factories. Businesses may also discover opportunities to improve efficiency, reduce costs or increase manufacturing capacity.

The Solution

With the adoption of various new technologies (Fig. 1), the future smart factory raises much higher demands on network performance, especially the throughput and latency. The rollout of 5G and its rapid commercial maturity ensures the actual deployment of smart factory and related applications. Fig. 2 explains the overall network architecture for the smart factory in Thailand.

For the network coverage of the smart factory, ZTE QCell solution is used to provide 5G coverage at 2.6 GHz. With 40 MHz bandwidth, the 5G QCell could provide the peak throughput of 250 Mbps and 40 Mbps for downlink and uplink respectively. As the 5G network deployed is fully used to serve the network connections of the smart factory, it can be considered as a private campus network that is independent from the 5G public network of AIS. With the existing transmission path, the 5G network of the smart factory can connect with the AIS 5GC located in Bangkok. In another data center at Rone, the application servers are deployed for the smart factory. In order to further enhance the network performance for the smart factory, ZTE MEC solution is also deployed at the same data center next to the application servers. They all adopt the ZTE cloud platform. In the exhibition hall of SUT, PCs and TVs are installed to monitor and show the images fed back by applications and robots in the smart factory. Three new routes are created to ensure the links between the exhibition hall, the smart factory, 5GC and application servers.

Fig. 1. Technologies adopted in the smart factory.

The smart factory has perfectly integrated 5G technology with the traditional production lines. The equipment in the smart factory is connected to the 5G network through 5G CPEs or 5G modules. The 5G industrial AGV adopts LIDAR + cloud enhanced visual positioning and navigation technologies. It can rapidly and precisely plan its moving paths and operate automatically, making it a vital tool to boost efficiency inside a factory, warehouse or on a production floor.

Facial recognition-enabled 5G inspection patrol robots perform the duties of a security guard by patrolling various areas and reporting suspicious activities.

5G cloud machine vision processes the images uploaded from different working positions with the centralized machine vision station deployed at the edge cloud and displays the status and control information of the equipment on a big monitoring screen. This solution responds to the key demands of product quality control, equipment management and production line monitoring that are widely present for modern manufacturing.

5G AR remote guidance enables work,

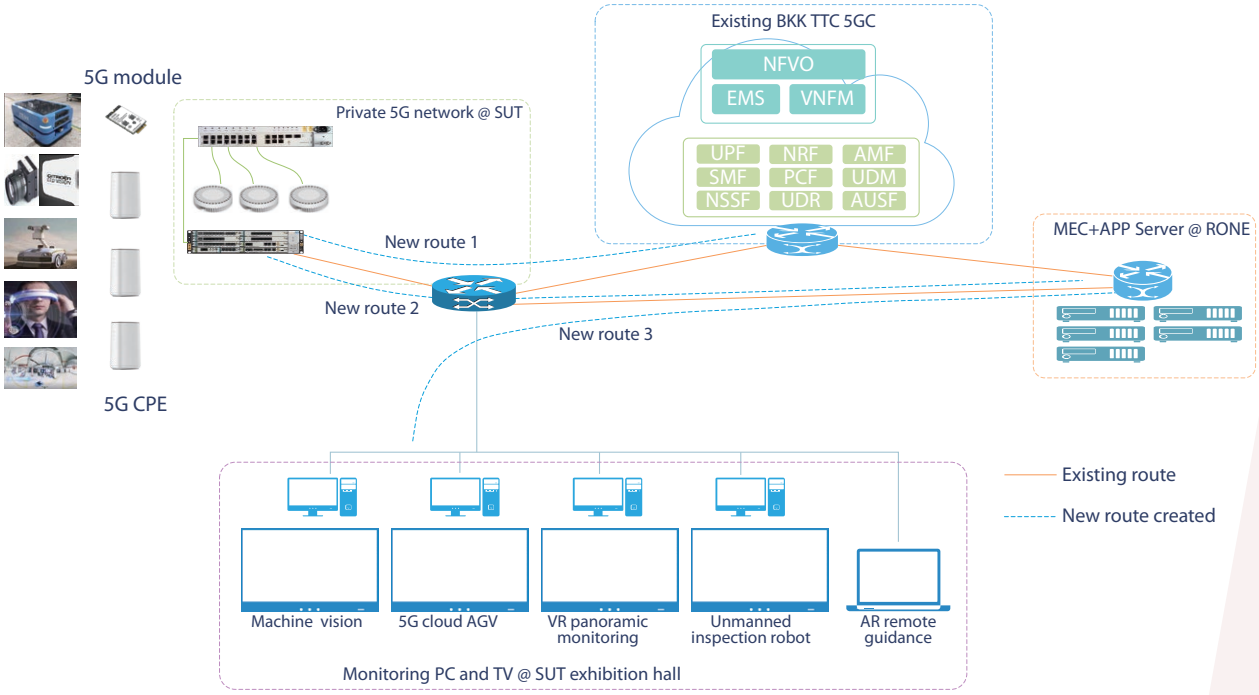


Fig. 2. Network architecture of the smart factory in Thailand.

training and repair functions to be performed remotely without physical presence on site of relevant parties.

Finally, 5G VR monitoring acts as a real-time quality assurance inspection tool to ensure the application of uniform product standard from raw material to finished goods.

AIS Chief Enterprise Business Officer (CEBO) Tanapong Ittisakulchai commented, "AIS was the first to launch 5G service in February 2020, as the operator holding the most spectrum in low, medium and high bands. Over 35 billion baht budgets are allocated by AIS for year 2020 and 2021 to cover 100% of the occupied zones in the EEC and key public health centers across the country for the battle against COVID-19. With ZTE and SUT, we have jointly developed solutions to better address the needs of the industry. This smart factory demo is based on 5G Total Solutions for Industry. We have deployed 5G SA digital infrastructure on 2.6 GHz with excellent properties to support this use case, including reduced latency to provide full support for IoT."

As the solution provider for the 5G smart factory, Ling Zhi, vice president for ZTE global marketing explained, "As a major international provider of telecommunication, enterprise and consumer technology, ZTE is willing to expand 5G intelligent manufacturing in Thailand. Together with AIS and SUT, we are providing industrial customers with the innovative solution, aiming to serve the enterprises with 5G based flexible and intelligent end-to-end solutions. Committed to empowering traditional industries with 5G, ZTE has carried out innovations with partners for 5G applications across over 15 key industries. Moving forward, together with AIS and SUT, we will help Thailand's manufacturing industry to evolve towards a green, low-carbon, digital, and intelligent future."

Summary

The smart factory demonstration in Thailand is the first appearance of ZTE 5G+ smart manufacturing solution in overseas markets. It showed that the 5G can catalyze the upgrade of traditional industries. ZTE will continue to work and cooperate with customers and partners to better use 5G technology for future social and economic development. ZTE TECHNOLOGIES

To enable connectivity and trust everywhere