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ZTE TECHNOLOGIES

VIP Voice

Smartfren's CTO Talks About Digital Transformation, Industry 4.0 and 5G

Expert Views

ZTE 5G FAST Solution to Meet Challenges of 3.5 GHz Network Deployments

Special Topic: 5G SA

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Cover Figure | Shurish Subbramaniam, CTO of Smartfren

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Smartfren's CTO Talks About Digital Transformation, Industry 4.0 and 5G

Reporter: Xiong Limin

Shurish Subbramaniam, CTO of Smartfren

Indonesia, as the largest archipelago in the world, has vast digital potential. To drive the digital economy, the Indonesian government officially launched the roadmap called "Making Indonesia 4.0". Smartfren, one of Indonesia's leading telecom operators, is well on its way to digital transformation. "This (digital transformation) is to ensure that telecom acts as the foundation to all communications/transactions and learning," said Shurish Subbramaniam, CTO of Smartfren.

In an interview with *ZTE Technologies*, the Smartfren CTO delved into the operator's accomplishments that encompass the operator's two-pronged approach for digital transformation, the industry 4.0 use case enabled by 5G, and also shared with us his considerations for 5G deployment.

How has the telecom industry evolved in Indonesia's market?

The telecom industry in Indonesia remains very competitive. ARPU pressure remains as a challenge. In the current pandemic situation, demand for data and digital solutions is high as well so service providers are continuously developing innovative products to support the consumers.

How important do you think is the digital transformation of businesses, especially in the post-COVID-19 period?

Transformation here will be related more to introductions of digital products or solutions to the market for both the consumer and enterprise. This is to ensure that telecom acts as the foundation to all communications/transactions and learning.

Customer experience is important for every operator and a key focus of a telco's digital transformation. How about your improvements in this area?

Customer experience is key to all telecom service providers and customers are demanding high service quality and innovative products. I can break it down into two parts: network and digital.

For the network part, we have enhanced our automation platform where we created multiple algorithms to ensure we automate key network related activities as much as possible to avoid any unwanted human errors that will impact customer experience. The automation being done for operations is to perform efficient maintenance as well as the planning & deployment for efficient execution and fast response to consumer demands.

For the digital part, we introduce more data analytics platforms with artificial intelligence for in-depth understanding of consumer's needs and behaviors and in return continuously develop new-age products to support new digital transformation.

In Smartfren we have started both the automation and data analytics journey to be ahead when it comes to customer experience.

What new-age products have you launched to support the digital transformation and tap into new revenue streams?

We have invested in connectivity management platform (CMP) to introduce IoT services. With this CMP platform we will be reaching out to enterprise customers to enable them to digitalize some of their services, i.e., working with power utility companies to introduce smart metering.

ZTE and Smartfren collaborate for 5G demonstrations.

How are you supporting the Industry 4.0 roadmap known as Making Indonesia 4.0?

We have successfully completed the 5G (28 GHz mmWave) trial using a drone with 5G backhaul as the use case. This was done by partnering with ZTE to demonstrate Industry 4.0. The drone here was used to troubleshoot a fault inside the factory where human movement is limited. We are looking forward for the right 5G spectrum allocation where we can start introducing more use cases to support the revolution.

What's your 5G roadmap in terms of SA and NSA and what technology or business challenges do you foresee?

5G remains a challenge in Indonesia due to availability of the popular spectrums. Indonesia being a country with multiple islands, still has a need for the spectrum to be used by satellite operators to provide necessary services. The 5G spectrum will be available once spectrum re-farming is completed. For now, I believe 5G will initially start with DSS technology using the existing cellular spectrums.

What is the most important 5G use case and what vertical will benefit most from 5G in Indonesia?

eMBB will be the main use case for 5G to provide higher spectral efficiency and deliver higher throughput and capacity for mobile users. Beyond that the other use cases will be around enterprise solutions focusing on manufacturing sectors.

What kind of role is ZTE playing in your 5G journey? What's your expectations for it in the future?

ZTE is our biggest partner when it comes to network solutions. We expect ZTE to ensure all new deployments are capable of upgrading to 5G seamlessly. ZTE TECHNOLOGIES

SuperDSS: An Effective Scheme for Integrating FDD NR Spectrum Resources in 5G Era

Zhang He
RAN Product Planning Director, ZTE

With the deep integration of new-generation information technologies represented by mobile internet, IoT and cloud computing with traditional industries, the broadband, ubiquitous, mobile and multi-standard characteristics of radio technologies have become more and more obvious. Various network standards such as GSM, UMTS, LTE, NB-IoT, eMTC and 5G coexist in the wireless network. Radio spectrum resources are crucial to mobile communication, and the frequency bands below 3G with the best coverage are non-renewable treasure in the radio bands. But in fact, there are some problems such as the coexistence of multiple modes and serious fragmentation in these frequency bands, which limit the use of them by 3G, 4G and 5G networks. Facing the challenges, ZTE has proposed SuperDSS, a unique scheme for tri-RAT dynamic spectrum sharing (DSS).

The Trouble of FDD Spectrum Refarming

The lower the frequency band, the longer the wavelength, and the farther the coverage distance. Therefore, in the early stage of wireless network development, 2G/3G/4G networks using the FDD mode basically occupy all low frequency bands.

With the increasing demand for user data and the development of wireless networks, countries around the world have begun to build 5G networks. However, the coverage of high frequency bands is weak, so it is necessary to build more sites and invest more to achieve continuous coverage of 5G networks. The urgent problem for operators is how to deploy 5G carriers in the lower frequency bands already occupied by 2G/3G/4G, improve 5G basic coverage and reduce construction costs.

At present, the solutions in the industry generally involve the following three aspects:

- **Spectrum refarming:** Consider disabling 2G/3G networks directly and refarming the spectrum to the 5G network. Although spectrum refarming is the most direct way, according to an operator's current network traffic statistics, 70% of existing voice service is still carried over 2G/3G networks.

Therefore, it is difficult to withdraw most 2G/3G spectrum for refarming.

- **Static spectrum allocation**: 2G/3G/4G/5G exclusively occupies a part of the spectrum, and the spectrum bandwidth obtained by each standard is limited. This way of division cannot leverage fully the advantage of 5G wide bandwidth, so it is of little significance.
- **Spectrum sharing:** At present, Magic Radio Pro, Cloud Air and DSS used in the industry solve the dynamic spectrum sharing between the two systems, but can not cope with the scenario where the three systems coexist at the same time.

SuperDSS: Improving 5G Spectrum Utilization and Cell Throughput

Considering 5G spectrum and 2G/3G features, ZTE has proposed the SuperDSS scheme. Under the premise of ensuring the service quality of traditional voice users under the limited spectrum resources, SuperDSS aims to dynamically realize the sharing of spectrum resources among different systems according to the service load, avoid spectrum fragmentation, and ensure that 5G network occupies as much bandwidth as possible to maximize its value. The scheme includes 3G/4G/5G dynamic spectrum sharing (Fig. 1) and 2G/4G/5G dynamic spectrum sharing (Fig. 2).

To implement the tri-RAT dynamic spectrum sharing, it is necessary to consider the following issues among multiple systems.

- **Principle of spectrum allocation:** 5G NR bandwidth is greater than or equal to 4G LTE bandwidth, and the spectrum bandwidth occupied by 2G/3G is less than that of 4G LTE. The NR/LTE bandwidth is greater than or equal to 15 MHz, and the total spectrum occupied by 2G/3G is not greater than 5 MHz.
- **Service priority:** As voice services have a high requirement for real-timeliness, it is necessary to give priority to 2G/3G users to occupy spectrum resources. LTE/NR users carry more data traffic (VoLTE/VoNR users have a higher priority than data users), so their priority is secondary. The priority scheduling between LTE and NR should be judged according to traffic load of the network itself. The higher the load, the higher the priority.
- **Interference avoidance:** Spectrum sharing is actually resource multiplexing. The resource multiplexing is divided into frequency division multiplexing, time division multiplexing, code division multiplexing, and space division multiplexing. Code division multiplexing and space division multiplexing are generally only used within the systems, while frequency

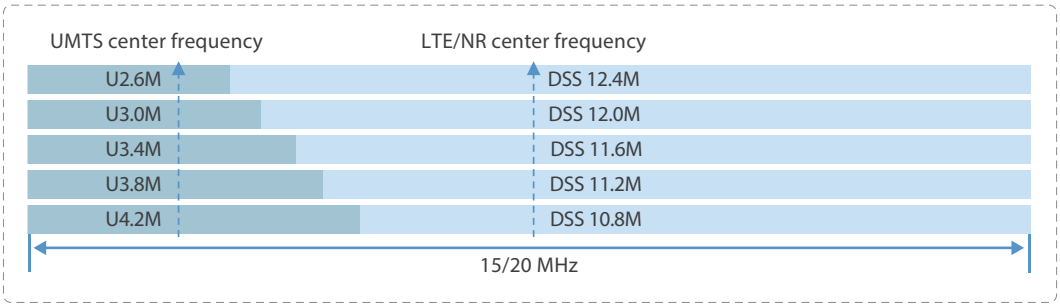


Fig. 1. 3G/4G/5G dynamic spectrum sharing.

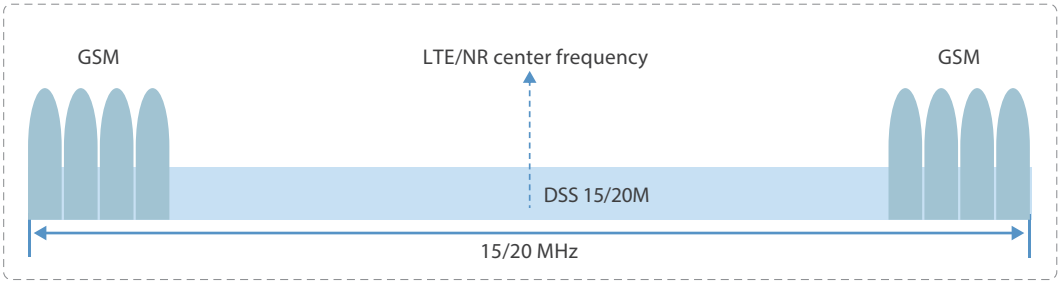


Fig. 2. 2G/4G/5G dynamic spectrum sharing.

division multiplexing and time division multiplexing can be applied within and between the systems. The dynamic spectrum sharing technology is a typical inter-system resource multiplexing. According to GSM/UMTS/LTE/NR technical features, the interference between 3G/4G/5G or 2G/4G/5G channels can be addressed by intelligent time-division and frequency-division scheduling algorithm, interference suppression and cancellation, as well as baseband and RF filtering.

- **Dynamic bandwidth adjustment:** The gain of dynamic spectrum sharing is mainly reflected in the change of dynamic bandwidth that enables LTE/NR to obtain more spectrum resources and thus improve spectrum utilization and cell throughput. There are broadcast carriers and service carriers in GSM cells. GSM BSC dynamically activates and deactivates GSM carriers according to BTS traffic conditions. UMTS cells generally have single carriers with a bandwidth of 5 MHz. It is impossible to directly deactivate UMTS carriers through RNC like GSM, otherwise UMTS users will lose network services. UMTS can dynamically compress the bandwidth from 5 MHz to 2.6 MHz through the baseband and RF filtering while ensuring the voice quality of UMTS users remains unchanged. The spectrum resources released by GSM/UMTS are used by LTE/NR to obtain capacity gain.

On the condition of effective spectrum resources, 4G/5G DSS can rapidly deploy 5G network while satisfying the current LTE capacity. However, SuperDSS can not only rapidly deploy 5G network, but also address the issue of FDD spectrum fragmentation and waste caused by 2G/3G/4G/5G coexistence. It can also bring operators the improvement in 5G network coverage and cell capacity as well as lower O&M costs.

SuperDSS Market Application

ZTE released its SuperDSS, the industry's first tri-RAT dynamic spectrum sharing scheme in February 2020. The scheme has attracted the attention of all parties in the industry. ZTE cooperated with Henan branch of China Unicom to complete commercial verification of the world's first 3G/4G/5G tri-RAT dynamic spectrum sharing solution in April 2020.

Field test results show that provided that the total spectrum bandwidth remains unchanged, SuperDSS gives priority to ensuring 5G user experience while taking into account 3G and 4G users, so that spectrum resources can be flexibly scheduled and allocated among 3G/4G/5G users. Compared with the statically allocated spectrum scheme, SuperDSS increases the total throughput by 35%.

SuperDSS is the core innovation of ZTE Magic Radio Pro for 5G evolution. This indicates that ZTE has reached a new level in the field of spectrum sharing, leading the development of the industry. ZTE TECHNOLOGIES

ZTE 5G FAST Solution to Meet Challenges of 3.5 GHz Network Deployments

Yuan Zhigui
Chief Engineer of 5G Network Technology at ZTE

5G network deployments are in a full swing around the world. The initial phase of 5G deployments focuses on eMBB. This puts very strict requirements on uplink capacity and transmission latency, which cannot be completely met with only the use of the 3.5 GHz band. To meet the challenges, ZTE proposes the FDD assisted super TDD (FAST) 5G solution.

3.5 GHz Spectrum Analysis

Spectrum is the core resource for mobile communications. The 5G spectrum is separated into multiple frequency ranges, each with its own characteristics that makes it suitable for the deployment of a certain service. The world's first commercial 5G networks are deployed with the higher frequency bands including 3.5 GHz (3.3-3.8 GHz, n78 band) and millimeter waves, and 2.6 GHz (2.496-2.69 GHz, n41 band). Compared with the main FDD-LTE bands such as 1.8 GHz (band 3), the 3.5 GHz TDD band has higher penetration loss and less available uplink time slots. Therefore, in meeting 5G service requirements, it faces three key challenges: uplink capacity, uplink coverage and transmission latency.

Uplink Capacity

With TDD mode, the uplink and downlink use the same frequency and are allocated different time slots. In China at 3.5 GHz, the uplink/downlink time slot ratio is 3:7, that is, 30% of the time slots is allocated for uplink and 70% of the time slots for downlink. Taking the 100 MHz bandwidth as an example, the equivalent uplink bandwidth is only 30 MHz, which is only 1.5 times that of the 4G single carrier.

Uplink Coverage

The higher the frequency, the greater

the space propagation loss and the shorter the coverage distance. For example, the uplink propagation loss in the 3.5 GHz band is 5 dB higher than the 2.1 GHz band. In addition, the higher the frequency, the greater the penetration loss, and the shorter the coverage distance.

Transmission Latency

With TDD mode, terminals cannot send uplink data while receiving downlink data, which results in an extra latency for uplink. For the 3.5 GHz band with 30% of the time slots used for the uplink, there will be an extra latency of 0 to 2 ms, with an average latency of 0.8 ms. Likewise, in the downlink direction, an extra latency of 0 to 1 ms and an average latency of 0.2 ms.

ZTE FAST to Improve Network Capacity and Coverage

Enhancing 5G uplink performance with lower frequency bands such as 2.1 GHz and 700 MHz has become a major concern for many operators. ZTE FAST 5G solution effectively improves 5G uplink and downlink performance through deep cooperation of FDD and TDD. Low-band FDD spectrum enables wider coverage and incurs no extra transmission latency but offers a lower bandwidth; mid-/high-band TDD spectrum provides a larger bandwidth that is further improved by the application of MIMO technology in both the uplink and downlink but inferior coverage and latency to FDD. For the terminals in the center of the cell (near point), FAST (as shown in Fig. 1) deeply aggregates the bands of FDD and TDD for simultaneous uplink and downlink transmission to achieve large throughput and low latency. For the terminals at the cell edge (far point), FAST enables them to switch to FDD band in uplink for better coverage while maintaining FDD and TDD carrier aggregation in downlink for higher data speed.

Based on the standard carrier aggregation framework which is already widely applied in 4G network, FAST introduces the innovative uplink

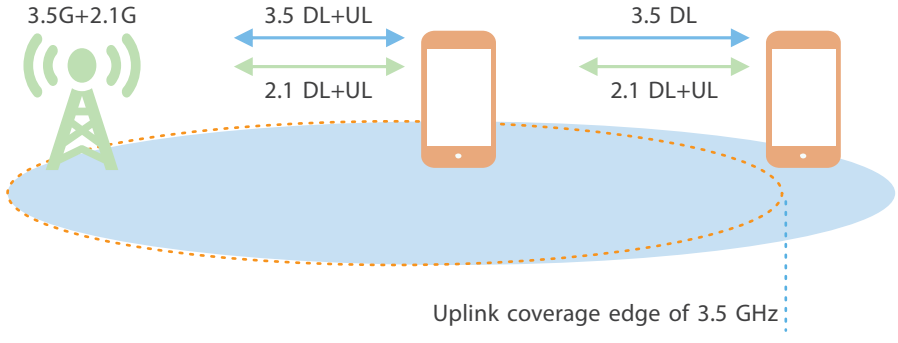


Fig. 1. Uplink and downlink transmission for a UE in the FAST solution.

TDM scheduling scheme to flexibly aggregate and coordinate FDD and TDD in time and frequency domains to enable spectrum to reach its full potential, thus solving the challenges of uplink bandwidth, uplink coverage and transmission latency.

Enhancing 5G Capacity

Assisted by 20 MHz bandwidth of the 2.1 GHz band, FAST allows a 3.5 GHz 5G network to improve a UE's uplink peak throughput and downlink peak throughput by 23% and 28% respectively. In the future, if 50 MHz bandwidth of the 2.1 GHz band is acquired, FAST can enhance the uplink and downlink peak throughput by 58% and 71% respectively.

A 5G terminal generally has up to two uplink transmit channels. For the TDD band, with the use of 2 × 2 MIMO in uplink, the equivalent throughput doubles. However, if a terminal utilizes the conventional uplink carrier aggregation technology to aggregate the FDD and TDD carriers, FDD and TDD can only use one transmit channel respectively, and the TDD uplink 2 × 2 MIMO will be disabled, which results in the capacity loss. FAST addresses this problem with the TDM scheduling scheme that reserves the 2 × 2 MIMO uplink capability for the TDD carrier. To be more specific, during the time of TDD uplink slots, the two uplink transmit channels work in the TDD 2 × 2 MIMO mode, and during the time of TDD downlink slots, the terminal will switch immediately to the FDD band. This scheduling mechanism uses nearly 100% of the uplink time slots without sacrificing the TDD 2 × 2 MIMO capabilities.

Improving 5G Coverage

When 5G is deployed over the 3.5 GHz band, the coverage bottleneck will first appear in the uplink direction whereas the downlink coverage is still acceptable. This 'asymmetry' between uplink and downlink restricts the coverage of 3.5 GHz and restricts the network spectrum efficiency. With FAST, terminals can connect simultaneously to both FDD and TDD carriers. On the cell edge, the terminal continues to benefit from the large TDD capacity in downlink while the uplink transmission will switch to the FDD carriers for better 5G coverage so that 5G services will be expanded beyond the TDD uplink coverage.

The deep harmonization of FDD and TDD provides larger coverage than a single TDD carrier and higher downlink data speeds than a single FDD carrier. Taking 2.1 GHz (FDD) and 3.5 GHz (TDD) as an example, the terminal can switch to 2.1 GHz in uplink when moving beyond the uplink coverage edge of 3.5 GHz, providing 2.3 times more uplink time slots than when there is only a single carrier of 3.5 GHz, and 2.5 times more downlink bandwidth than when there is only a single 2.1 GHz carrier.

Reducing 5G Latency

With FAST, the terminals can be flexibly scheduled to transmit data on FDD and/or TDD carriers. The downlink and uplink time slots are both 100% available without introducing extra schedule-waiting latency, which reduces the transmission latency. Taking uplink for an example, the average uplink

transmission latency of the 3.5 GHz TDD single carrier is about 2.2 ms, which can be reduced by 31% to 1.5 ms with FAST.

Flexible, Easy Networking

FAST is the mainstream solution for 5G NR to facilitate the 5G commercialization. First, it supports inter-sector and inter-site TDD/FDD coordination. Unlike other uplink enhancement solutions, FAST does not have the mandatory FDD and TDD co-site requirement for 5G deployment. Second, there is no tight binding between FDD and TDD carriers, that is, an FDD carrier can deeply be aggregated and coordinated with multiple TDD carriers, and vice versa. Each combination of TDD and FDD carriers is established dynamically for a particular terminal.

In the scenario where FDD is not co-sited with TDD or the coverage of FDD and TDD does not completely overlap, the flexible scheduling technologies, including the static codebook and two PUCCH groups, can be enabled by FAST to ease the deployment restriction.

In November 2019, ZTE and China Telecom completed the verification of the industry's first FAST solution at 2.1 GHz and 3.5 GHz, showing that the uplink rate of a single user can be up to 40% higher than that of the 3.5 GHz single carrier. The uplink switching for carrier aggregation proposed by FAST has already been standardized in 3GPP Release 16, and it is expected that this technology will be widely supported by the industry chain to help operators build better networks. ZTE TECHNOLOGIES

5G SA: Empowering Digital Transformation Across Industries

Bai Gang

Vice General Manager of RAN Products, ZTE

With the curtain on 5G pulled back in 2019, the pace of 5G deployment is accelerated worldwide. On the one hand, 5G will deliver higher capacity to meet the growing demand for mobile data; on the other hand, the smart internet of everything (IoE) infrastructure with 5G at its core will gradually take shape in the next few years, empowering digital transformation in every industry.

Standalone (SA) 5G will play a key role in the digital transformation of industry. A survey published by GSMA at the end of 2019 found that about 70% of operators plan SA launches in three years. While 2019 was the first year of 5G commercialization, 2020 is the first year of 5G SA.

5G SA Empowering Vertical Industries

In recent years, worldwide operators have encountered growth bottlenecks, witnessing a continuous decline in mobile service revenues from consumers with their consumer-related business reaching the ceiling. For operators, 5G's biggest new growth opportunities may lie in the enterprise verticals rather than the consumer market. The integration of 5G and vertical industries will enable new services and business models beyond imagination. Service innovation across vertical industries has put new requirements on the network infrastructure, such as network slicing, edge computing, ultra-low latency and massive connections, many of which can only be met with 5G SA networks.

To date, the ecosystem participants have made a lot exploration on expanding 5G into traditional industries, and we are seeing the emergence of

smart city, smart manufacturing, smart transportation, smart education, and other innovative use cases. It has become the industry's consensus that while the consumer market remains a cornerstone, the enterprise market is the future.

SA Ecosystem Now Ready

For operators who rolled out 5G in 2019, NSA was the only option. By 2020, the SA ecosystem has matured to enable large-scale deployment. In terms of standards, while the 3GPP Release 15 defines 5G NR, 5GC, and opens multiple NSA and SA deployment options, Release 16 frozen this July expands the reach of 5G to vertical industries. Major chipset vendors have released chipsets with 5G SA support, and major smartphone vendors have launched commercial NSA/SA dual-mode smartphones that cover the gamut from low-end to high-end with an entry price well below USD 250. In terms of system equipment, all the leading vendors have released 5G RAN and 5GC products supporting SA. In early 2020, China's three major operators kicked off large-scale 5G SA deployments in all mainstream 5G frequency bands (3.5 GHz, 2.6 GHz, 2.1 GHz, and 700 MHz soon) by utilizing innovative technologies such as dynamic spectrum sharing (DSS) and network sharing. In total, more than 600,000 gNBs will be rolled out, and their 5GC networks will have a capacity of more than 100 million subscribers, further boosting the maturity of the 5G SA ecosystem.

The Path to 5G SA

Depending on their choices of 5G launch time and business strategy, operators can either begin with NSA first, migrate to SA over time, or go straight to 5G SA. For those operators who are planning to launch 5G post-2020, they can go straight to 5G SA to significantly reduce the complexity of network operation and maintenance, minimize future evolution costs, and get involved early in service innovation for vertical industries. Operators who already have launched NSA 5G can migrate smoothly from NSA to SA through NSA/SA dual-mode architecture, ensuring a smooth experience for both existing NSA subscribers and new SA subscribers.

For 5G SA implementation, continuous NR coverage is required. However, the 3.5 GHz (n77/n78) band, due to its propagation characteristics, has difficulties in offering adequate coverage especially in some indoor scenarios. To solve this issue, it is highly recommended to use a FDD low band to provide a coverage layer for 3.5 GHz deployment. ZTE's FDD assisted super TDD (FAST) solution aggregates those two types of bands while introducing the innovative uplink TDM scheduling to enhance user

experience. If operators are not able to use dedicated FDD bands for 5G NR, they can use DSS to deploy 5G and 4G in the same band; however DSS does not address the more challenging yet important scenarios where 2G/4G/5G or 3G/4G/5G dynamic spectrum sharing is required for maximum spectrum utilization. That is why ZTE has developed its SuperDSS solution to better meet operators' requirements.

SA Practices in China

The Chinese operators have always been the pioneers in 5G SA. At the beginning of 2020, the Chinese government called for faster construction of new infrastructure such as 5G networks, which accelerates the migration to SA 5G. In the first half of 2020, China Mobile, China Telecom, and China Unicom have all completed the second round of their 5G tenders, covering SA core equipment and base stations. From 2020 onwards, all the newly deployed 5G base stations will be either in SA or NSA/SA dual-mode, and those NSA base stations deployed earlier will be gradually upgraded to NSA/SA dual-mode or SA. It is expected that China's three major operators will launch commercial 5G SA service in the second half of 2020, and for that to succeed, they have made a lot of preparation in collaboration with equipment vendors and industry partners.

In Guangzhou, China Mobile partnered with ZTE to verify the performance difference between SA and NSA. In the same wireless environment of Pearl River New Town, and based on the same set of devices, SA proved to offer better performance than NSA, including 50% improvement in the average uplink data rate, 15% in the average downlink rate, and shorter control plane/user plane latency.

In Fuzhou, China Mobile and ZTE jointly rolled out the world's first NSA/SA dual-mode network, and verified in detail the performance of various terminals in the dual-mode network.

For the fast commissioning of E2E slices in a multi-vendor environment, China Mobile, together with industry-leading vendors including ZTE, have developed a two-phase solution, which adopts a simplified architecture in the first phase to enable rapid time-to-market of slicing service, and puts slicing management online in the second phase for automatic deployment.

To improve the coverage of the 3.5 GHz band, China Telecom and China Unicom plan to deploy NR on the 2.1 GHz band with DSS. ZTE and the two operators have verified SuperDSS in the 2.1 GHz band, and FAST solution at 3.5 GHz and 2.1 GHz.

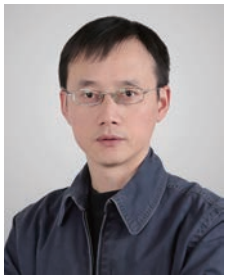
In Chengdu, China Telecom, together with ZTE and leading chipset vendors, have verified the end-to-end interoperability under the SA architecture based on the latest 3GPP standards.

For the vertical industry, the three operators have developed a lot of innovative cases together with industry partners. For example, China Unicom, Tianjin Port and ZTE developed a smart port. China Mobile, Xinfengming Group and ZTE built a smart textile workshop. China Telecom, Baidu and ZTE teamed up on self-driving cars.

Summary

As a global leading 5G supplier based in China, ZTE has been committed to promoting China's 5G SA deployment. ZTE also hopes to expand cooperation with global operators to build the future digital society by virtue of its cutting-edge 5G products and extensive experience in network construction. ZTE TECHNOLOGIES

5G SA Core: Connecting Everything Simply and Intelligently



Lu Guanghui

Chief Engineer of ZTE 5G CN Products

5G commercial launch has begun all over the world, with 2019 recognized as the first year of 5G NSA commercial launch and 2020 as the first year of 5G SA commercial launch. Compared with 4G, 5G SA aims to achieve internet of everything (IoE). Therefore 3GPP defined three major scenarios: eMBB, uRLLC and mMTC, to enable man-to-man, man-to-thing and thing-to-thing communications. The new goal raises new requirements for 5G core networks. 5G SA Core needs to be more accurate, intelligent, flexible and simple.

Challenges

As driven by the industry chain, the SA-based 5G Core will be commercialized on a large scale in 2020. Its commercial solution needs to meet the requirements of operators for efficient commercial use, as well as the differentiation and evolution needs of multi-waves in vertical industry applications. The key challenges are as follows:

- **Slow E2E service provisioning:** Due to the epidemic, enterprises need cloud-web synergy to achieve rapid cloud access. However, the actual network provisioning speed cannot keep up with cloud opening in minutes, and the network lacks automation of E2E service provisioning and operations.
- **Weak network customization capability:** The significant difference between 2C and 2B businesses requires that 5G Core should be more agile and can achieve fast network customization. Traditional pre-defined networks can hardly adapt to the wave of digitalization, leading to the bottleneck of innovation on the network side.
- **Differentiated requirements in vertical industries:** 5G network meets not only the needs of individuals but also the needs of various industries. Unlike individual needs, the needs of industries vary greatly from industry to industry. 5G Core needs to provide differentiated and guaranteed network capabilities on demand.

5G Cloud Core

To meet the challenges, ZTE has launched 5G SA Core, an accurate core network solution based on the 5G Common Core. Centering on the concept of full convergence, intelligence and simplification, the solution realizes capability construction and sustainable evolution of the core network, so it can

rapidly deploy 5G for operators, make full preparation for the long-term development of vertical industries, and help operators improve their competitiveness in the 5G IoE era.

Convergence is Foundation

5G Core uses converged network elements as well as simplified functions and interfaces to support full-scenario access and on-demand customization, meeting differentiated network requirements. The deployment of 5G Core needs to consider the convergence of network elements as much as possible, which includes:

- **4G/5G interoperability:** supporting unified user data, policy control, session anchor and forwarding anchor
- **Multi-access convergence:** supporting the convergence of 2G/3G/4G/5G network elements for unified services
- **Multi-scenario convergence:** supporting Options 2, 3, 4, 5 and 7 for full-scenario deployment.

Intelligence is Core

Through the full-process intelligence and automation, the 5G SA Core solution promotes the transformation of operation and maintenance (O&M) that involves network planning, deployment, O&M and optimization. It integrates the whole tool chain to implement intelligent and automated planning, design, deployment, and acceptance tests of 5G Cloud Core, significantly shortening the time of construction. Through a user-friendly interface, the solution achieves zero-distance interaction between tool functions and customer requirements in the whole life-cycle of network integration, helping operators solve their pain points in virtualized network integration.

- **Design tool:** It collects configuration parameters and resource requirements necessary for hardware, cloud platform, and MANO and NF deployment through the GUI, and automatically generates parameter files and design documents for integrated scene component instantiation.
- **Deployment tool:** It receives the instantiation parameter file generated by the design tool, intelligently deploys hardware, cloud platform, MANO and NF, and completes data configuration for NF.
- **O&M tool:** It implements routine maintenance and supports root cause analysis (RCA), automatic network inspection, fault self-healing and automatic work-order assignment, after the cloud platform, MANO and NF are deployed.

Simplicity is Key

Multidimensional slicing and DIY private network slicing are key capabilities for 5G SA architecture. Through automatic creation of dynamic slicing, network resources can be scheduled for rapid customization to address differentiated SLA. Thus, differentiated network requirements can be met in various vertical industries.

To deploy slices as soon as possible, a simplified solution is required that can give priority to implementing end-to-end slicing in the core and RAN part. At the early stage, operators focus on typical eMBB slices such as HD video and AR/VR, and adopt the edge deployment of the user plane of the core network to meet certain ultra-low-latency service requirements. At this stage, slicing can be combined with industry application demonstrations to fully verify that 5G slices meet the differentiated SLAs in different scenarios (Fig. 1).

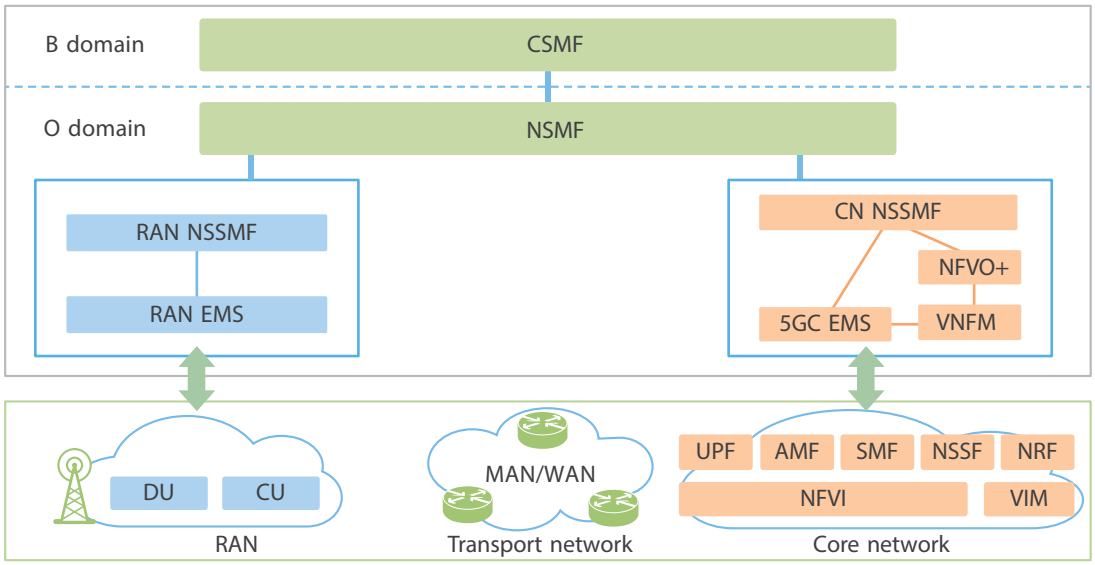


Fig. 1. 5G slices meet the differentiated SLAs in different scenarios.

With the maturity of 5G slicing standards, transmission and RAN sub-slices are introduced into the end-to-end network slicing. Slice design as well as guaranteed analysis and strategy are also added to the orchestration management system built in the early stage to provide full life-cycle management of the end-to-end slicing. While implementing slicing services, its operation mode needs to be considered, including slicing delivery, pricing, billing, and capability exposure, to accumulate experience and technologies for commercialization.

Evolution is Trend

In response to the rapid commercial needs of the first wave of eMBB and the differentiated needs and evolution challenges of the second or even more waves of vertical industry applications, 5G Core needs to evolve to support multi-dimensional 5G industrial packages and enable thousands of industries.

- 5G and TSN are used to build an accurate network to enable real-time industrial IoT. Typical scenarios include intelligent orchestration of assembly lines, campus robots, accurate vehicle scheduling, and coordination of wind generators and rotors.
- NPN is used to build a secure, reliable and tailor-made 5G private network. Typical scenarios include industrial parks, mines, and container ports.
- 5G LAN is used to rapidly deploy a secure and controllable enterprise LAN. Typical scenarios include large conferences, games, disaster relief, and remote office.
- Dedicated 5GC is used to build a low-cost and customized 5G network. Typical scenarios include various industrial applications that require high customization and security.

Through continuous cooperation with industry-leading operators, ZTE is accumulating more experience in 5G SA Core. Up to now, it has cooperated with more than 70 operators around the world with its leading products and solutions. ZTE is commercially deploying 5G SA Core on a large scale, making every effort to help leading operators offer 5G and make them be more competitive in the 5G IoE era. ZTE TECHNOLOGIES

NSA&SA Hybrid Network

Boosting Large-Scale 5G Deployment

Wei Tao

RAN Product Solution Manager, ZTE

The first 5G NR NSA standard was officially frozen at the 3GPP plenary meeting #78 in Lisbon, Portugal in December 2017. At the 3GPP plenary meeting #80 in Santiago in June 2018, the first 5G NR SA standard was officially frozen. This means that the global mobile communication industry is about to carry out full-scale 5G NR deployment, and the 5G era is coming.

Because the NSA standard is six months earlier than the SA standard, and terminals support the same pace, most operators select the NSA standard to deploy 5G networks in the early stage of global 5G deployment. Although NSA deployment can accelerate the commercial use of 5G, NSA technology limitations restrict the full development of 5G service potential. In particular, the adjustment between 4G and 5G in the deployment phase restricts and affects each other, greatly increasing network deployment costs. URLLC, slicing, new QoS mechanisms, and edge computing all require ultimate standard SA.

However, the direct change from NSA to SA results in the failure of early-stage NSA terminals to work in SA networks, greatly affecting 5G construction and promotion. Therefore, the smooth transition from NSA to SA becomes the focus of operators. The NSA&SA hybrid network can solve this difficulty.

The NSA&SA hybrid network allows multi-mode terminals (4G, NSA, NSA&SA, and SA) to coexist in the network at the same time, completely solving the bottleneck problem in which multi-mode terminals cannot adapt to the 5G network (Fig. 1). The priority of network resources can also be guaranteed for NSA&SA and SA terminals. For example, if there is no mandatory restriction on the network side, the terminal will prefer the SA mode to access the network. The performance of the 5G NR side is outstanding, especially on the uplink side, which will be 50% higher than that of the NSA uplink.

The Chinese government proposed the strategy of speeding up 5G deployment, and

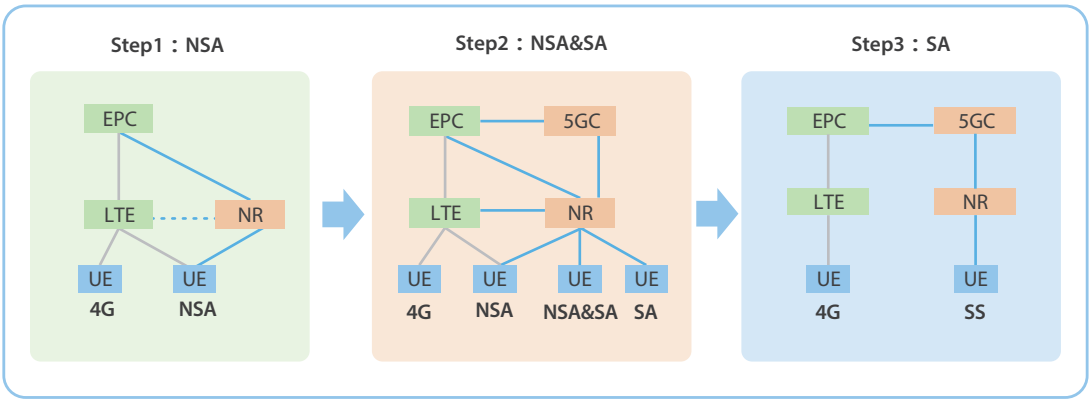


Fig. 1. NSA&SA hybrid network.

gradually put it into practice based on the NSA model in 2019. China's network conversion experience is worthy of reference. The 5G commercial use and the maturity of the NSA industry chain in China are all ahead of the SA development. The SA network is expected to be a long-term process in the industry. China sold tens of millions of 5G handsets in 2019, but most of them only support NSA. Operators need to consider the compatibility of these users and NSA handsets roaming to China in overseas markets, as well as the increasing demands for 5G applications in the industry.

China's 5G construction is represented by China Mobile. With more than 3 million base stations and more than 900 million mobile users, China Mobile is the largest operator in the world. Its 5G deployment experience is a reference model for global operators. China Mobile responds positively to China's national 5G development strategy. To meet the needs of initial NSA and evolved SA users, China mobile actively promotes the NSA&SA hybrid networking solution for smooth evolution from NSA to SA in the industry. Its 5G network can be deployed in the following three stages:

- **Stage 1:** In 2019, China Mobile started 5G deployment to integrate necessary resources for network development and verify its commercial performance. Considering the actual 5G development and China's market competition, combined with the maturity of its industry, China Mobile uses different network architectures to meet the needs of different stages of network development. Its 5G network started with NSA for friendly users in key cities. In the early stage, China Mobile made friendly users use NSA single-mode terminals and sent a clear signal to the industry that SA was the target network.
- **Stage 2:** In 2020, China Mobile entered the stage of large-scale 5G deployment. The scale of its eMBB users began to grow, while SA was fully deployed. Its NSA users attracted in the first stage of 5G deployment in 2019 will face the problem of terminal replacement, which will have a great impact on China Mobile's brand building and operational costs. Therefore, developing the NSA&SA hybrid networking mode is an important transition stage for the evolution from NSA to SA in key cities.
- **Stage 3:** China Mobile will develop vertical industry users. It will promote the applications of 5G industry users, enrich 5G business models, and transition to SA networking.

Together with China Mobile, ZTE has built the world's first 5G NSA&SA hybrid commercial network in China's Fuzhou University City. Based on 3GPP standards, this network implements end-to-end NSA&SA dual-mode access from the core network, RAN, to 5G terminals, providing users with a high-speed 5G network experience that is not restricted by the 5G terminal system anytime and anywhere. After thorough tests and network optimization, the current network fully meets the performance requirements after NSA and SA terminals are connected at the same time in commercial mode, bringing an average download rate of over 1 Gbps and better 5G experience to users. The test shows that the performance and user experience of NSA&SA dual-mode sites are basically the same as those of single-mode SA or NSA site. The NSA&SA dual-mode capability can effectively protect the investment of operators and ensure both NSA and SA user experience. The construction of 5G NSA&SA dual-mode networking and network optimization also provide China Mobile with valuable dual-mode commercial experience and more comprehensive technical accumulation in the study of smooth evolution of 5G network.

China Mobile plans to deploy over 300 thousand 5G base stations in 2020, and will fully deploy SA on a large scale to accelerate the evolution from NSA to SA target network and ensure the provision of 5G SA commercial services in all prefecture-level cities in China within 2020. As a bridge of evolution, the NSA&SA hybrid network will help China Mobile deploy 5G networks on a large and efficient scale. ZTE TECHNOLOGIES

SSB 1+X Beam Networking Solution for 5G Networking Optimization

Wang Xiangke

Wireless Product Solution Manager, ZTE

When a wireless system is changing people's lives, its technology itself is also developing and evolving. From 2G, 3G, 4G to 5G now, the application of each new technology has brought a great enhancement in air interface capacity of the wireless system. The 5G air interface uses Massive MIMO to maximize the space division multiplexing of spectrum resources through beamforming, which greatly improves the spectrum efficiency and cell capacity. However, a large number of flexible beams increase the complexity of the wireless system. If there is no efficient beam management and planning, the entire wireless system will be adversely affected. The increasingly complex wireless environment and urban construction growth also pose challenges to 5G coverage. Typical coverage scenarios include general wide coverage, high-rise building coverage, hot venues coverage, and highway coverage. How can 5G achieve better coverage in different scenarios while reducing intra-system interference and enhancing user experience?

As the coverage of a cell is determined by the coverage of cell broadcast, controlling the coverage of a broadcast beam is the key to 5G coverage.

To achieve high-quality 5G coverage, ZTE has proposed the SSB 1+X beaming networking solution, in which "1" represents a wide beam configured for basic horizontal coverage and "X" refers to narrow/wide beams configured on demand for vertical coverage extension. In this solution, different SSB (SS/PBCH blocks) beams are used in different cells to stagger inter-neighbor interference for horizontal coverage. According to coverage requirements, more beams are used for spatial coverage in the vertical dimension to achieve the best 5G coverage (Fig. 1).

The SSB 1+X beam networking solution is designed to improve coverage, save sources, reduce power consumption and control interference, and can finally get the best user experience with high performance-to-price ratio.

Improve Coverage

The SSB 1+X beam networking solution uses the minimum horizontal SSB beam and on-demand vertical beams to achieve 3D full space coverage and in-depth coverage extension and adapt to various coverage scenarios in complex environments.

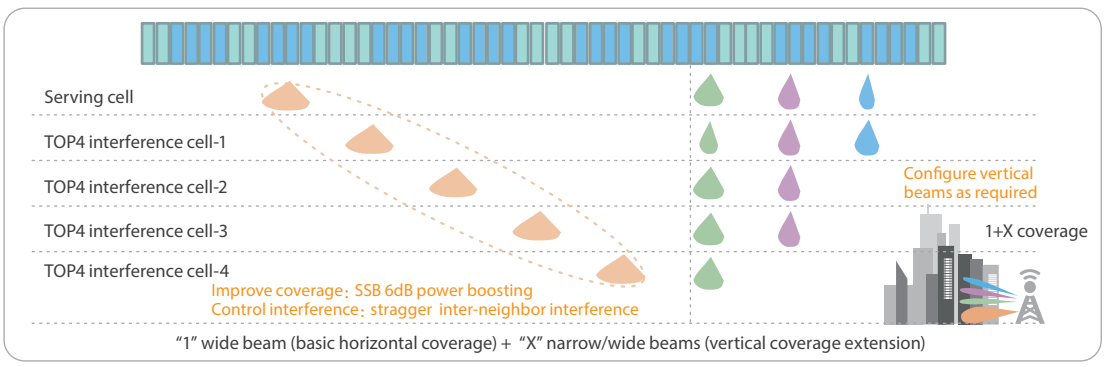


Fig. 1. ZTE's SSB 1+X beam networking solution.

The solution improves horizontal beam gain through the SSB power boosting and increases SSB 1 beam gain by 6 dbm. In this way, the horizontal wide SSB 1 beam provides the same coverage as the horizontal SSB 8 beams, and more SSB beams are reserved for vertical coverage.

Save Resources

In the 5G system, the beams corresponding to SSB are distinguished through time polling. Multiple SSB beams correspond to multiple SSB time-domain positions. One slot can be configured with two SSB beams, and one SSB occupies four OFDM symbols in the time domain. One SSB occupies 20 PRB resources in the frequency domain. In the general wide coverage scenario, SSB 8 beams are configured horizontally, and SSB beams occupy four slots. The corresponding system messages SIB and Paging also need to broadcast 8 times, and thus occupy 8 times the wireless resources.

The SSB 1+X beam networking solution adopts horizontally SSB 1 beam configuration mode to meet the coverage requirements. Therefore, the horizontal configuration of SSB 1 beam requires only four OFDM symbols in one slot in the time domain, and system messages SIB and Paging only need one set of wireless resources, which greatly saves the wireless resources occupied by sending messages.

After data analysis, the SSB 1+X beam networking solution can save about 6% of the total wireless resources compared with the horizontal SSB 8 beams solution. In particular, for the initial access phase, the SSB 1+X beam networking solution can save wireless resources by 34%.

Reduce Power Consumption

The SSB 1+X beam networking solution occupies less wireless resources, thus greatly reducing 5G power consumption.

The SSB 8 beams solution is compared with the SSB 1+X beam networking solution according to the period of 20 ms. When SSB 8 beams are configured, the mark-space ratio of wireless resources is 76.92%. When the SSB 1 beam is configured, the mark-space ratio of wireless resources is 11.30%. The lower the mark-space ratio, the less resources the system needs. The difference of the mark-space ratio between SSB 8 beams and the SSB 1 beam is 65.62%. The SSB 1+X beam networking solution can save the power consumption of AAU by nearly 10% compared with the SSB 8 beams solution.

With the expansion of 5G deployment in China, the SSB 1+X beam networking solution used by hundreds of thousands of 5G sites nationwide will greatly reduce long-term 5G operation and maintenance costs for operators.

Control Interference

The broadcast interference between neighboring cells in a 4G network has always been a key issue to improve network performance. Neighbor cell interference also exists in 5G network deployment. Through continuous algorithm demonstrations, the SSB 1+X beam networking solution proposed by ZTE can solve the problem of adjacent interference.

5G adopts horizontally the configuration of SSB 1 beam, while different SSB beams are sent through time polling. Therefore, different SSB beams are configured for neighboring cells, and the transmission time of SSB beams between neighboring cells is staggered through the time polling. This can avoid broadcast interference between neighboring cells.

In addition to broadcast interference between neighboring cells, interference also exists when conflicts occur between broadcast beams and service beams in neighboring cells. The interference also has a negative impact on user experience. To avoid the interference, ZTE has put forward the inter-neighbor rate matching configuration function based on the 3GPP 5G protocol. If there is a conflict in neighboring cells between service channels and SSB beams, the rate matching function at the symbol level is enabled for service beams to avoid the interference and improve user experience.

With the large-scale deployment in 2020, 5G network coverage and optimization will face great challenges. The SSB 1+X beam networking solution will help operators optimize 5G network, improve its performance, and achieve high-quality 5G growth. ZTE TECHNOLOGIES

Building Low-Carbon Networks with AI-Based Power Saving

Fan Yingying

RAN Solution Manager at ZTE

As mobile networks enter the 5G era, new technologies, services and applications continue to emerge. With revolutionary advantages over 4G networks in key performance indicators such as transmission rate, delay and connection, 5G networks can support more abundant services and applications, but also bring the challenges of growing Capex and Opex to mobile operators. A report from GSMA forecasts that deploying 5G networks in a given scenario will consume at least 140% more electricity than 4G networks. In a typical network operation, wireless sites consume about 45% of the total network power consumption, among which BBUs and RRUs/AAUs consume about half or more of the power consumption. Therefore, reducing power consumption of base stations is crucial to network energy saving.

Traditional power-saving methods require manual analysis of massive data, including common parameter data, network inventory, feature adaptation, site co-coverage, and multi-band multi-mode network identification. During the implementation, strategies of power saving in a specified area will be a unified manual operation. Because there is no differential setting of the parameters, it is impossible to automatically match different network scenarios or site traffic. In some sites during busy hours, this may cause damage to services and affect network performance, while other sites cannot maximize power saving in idle hours.

With the help of AI and big data technologies, ZTE's AI-based power saving solution implements coordinated power saving in different scenarios, different sites, different time, and different systems of networks. While ensuring network KPIs, the solution can maximize power saving and achieve the best balance between power consumption and network performance.

In the AI-based power saving solution, traffic load prediction, strategy adjustment and optimization, real-time KPI and performance monitoring will form a closed loop, which includes initial parameter self-configuration, time window self-adjustment, and threshold self-optimization (Fig. 1). Through the precise insight into network and user behaviors, the solution can intelligently identify real user usage, thus reducing power consumption.

Initial Parameter Self-Configuration

The initial power saving strategy can be self-configured according to characteristics of base stations and the relationship between power saving functions. Through big data analysis, the system

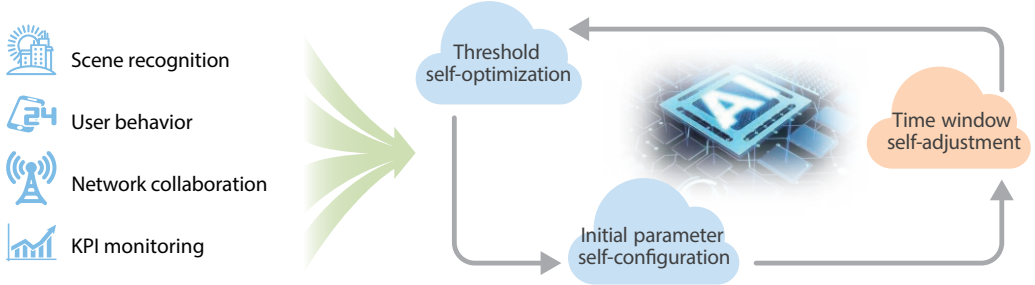


Fig.1. AI-based power saving solution.

automatically sorts out mainstream network scenarios, and analyzes the power-saving scenarios according to the historical traffic model and base station configuration. According to user behavior habits, site hardware equipment and power-saving function constraints, the power-saving effect is estimated and the initial power saving strategy is made to realize self-configuration. The suitable power saving strategy including a relatively proper initial threshold and a time period for executable energy saving will be enabled for the sites that are expected to have power saving effects.

Time Window Self-Adjustment

Based on historical traffic data, three types of cells are distinguished: positive cells, negative cells and invalid cells. The intra-week sub-sequence split prediction is combined with the impact of holiday factors and network traffic load trend on prediction. After testing the well-known time series prediction algorithm like linear regressive, ARIMA and long-short term memory, the second-order exponential smoothing algorithm is chosen to get the prediction model with the best computational performance and optimization effect.

The result of commercial use case shows that the prediction accuracy of uplink/downlink PRB ratio and RRC connected users exceeds 90%. The prediction value matches well with the actual value in normal scenarios, which effectively increases the efficiency of power saving in the specified period.

Threshold Self-Optimization

To find the balance between power saving and network performance and maximize the power saving effect, the precise cell-level scenario-based triggering and parameter setting replaces the traditional inflexible network-level parameter setting. Clustering algorithm will be used to find out the best step of power saving threshold adjustment through 96 groups of KPIs including setup success rate, call drop rate, handover and user experience per cell every day. After the AI self-learning, the baseline of KPI will be updated daily, and the threshold will be adjusted according to the step. In case the KPI baseline is exceeded, the threshold will roll back in real-time.

The convergence between power saving effect and network performance will achieved within one week after commercial application is testified.

Since mid-2019, ZTE's AI-based power-saving solution has been widely deployed for commercial use by operators in many places of China, including Shandong, Chongqing, Sichuan, Fujian, Hunan and Liaoning, with a cumulative application scale of more than 100,000 cells. Its commercial networks in overseas countries such as Malaysia, South Africa and Italy are also deployed and verified. As testified in commercial use, the AI-based power saving solution can reduce power consumption of the base station by 15 to 20%. In 5G networks, 6 hours of deep sleep combined with 18 hours of symbol shutdown can save 30% of power. In other words, every 1000 sites can save 1.5 to 2 million kilowatt-hours a year, equivalent to about 1.5 to 2 million yuan or 1100 to 1500 tons of carbon emissions.

The intelligence of the whole network is difficult to be achieved overnight and needs a long-term development. However, with the continuous accumulation of commercial network data, the machine-learning algorithm will gradually improve the AI-based power-saving solution. The AI algorithm itself will evolve iteratively to achieve higher efficiency and more accurate strategies to adapt to changes in network topology and traffic models.

The following suggestions can be considered for improvement:

- Feed back to vendors to design more intelligent devices and make them more adaptive.
- Make consumer products such as mobile phones and mobile phone software more intelligent in the use of power and signal strength and work in synergy with the network.
- Make the design of vendor equipment more integrated with AI to reduce power usage.

The development of IoT and enterprise networks is a big issue at present. More carrier-grade solutions are deployed in enterprises, and the demand for services in different vertical industries is growing. The power-saving requirements in these scenarios will be unique and more complex than those in cellular networks for individuals. ZTE TECHNOLOGIES

Industry Application Practices Based on 5G SA

Li Wei

5G Industry Marketing Director, ZTE

Guo Ting

5G Industry Branding Director, ZTE

2020 is the first year for commercial use of 5G SA in China. Chinese operators are accelerating the evolution to SA target network, which is a new stage for them to lead 5G development. 5G R15 released in 2019 has already supported the standalone (SA) mode. At the 88th meeting of 3GPP TSG, 3GPP announced the freeze of 5G R16, marking the official completion of the first 5G evolution version. 5G R16 will bring higher efficiency and performance, enrich 5G industry application scenarios and accelerate the global 5G industrialization.

5G SA provides plenty of opportunities for operators to develop both B2C and B2B services in the new era. To obtain more industry users, it is necessary to focus more precisely on application scenarios and find their business pain points and key problems, so as to solve problems with differentiated solutions, create value with precise services and achieve win-win results. Therefore, ZTE has adhered to the concept of deploying cloud on demand and networks with cloud to create precision cloud-network convergence solution that enables industry innovation and upgrade, and has carried out extensive practices with partners.

World's First 5G SA Wireless PRB Slicing for Metro

Guangzhou Mobile, ZTE and Guangzhou Metro jointly implemented the world's first 5G SA wireless physical recourse block (PRB) hard isolation slicing solution at the Canton Tower Station of Guangzhou Metro in May 2020, covering 5G terminals, 5G NR, 5G transport and 5G core network. They built an end-to-end 5G slicing, marking the official application of sliced-based 5G private network in the Metro field. As compared to slicing based on QoS, PRB-reservation based slicing provides hard isolation of dedicated wireless spectrum resources and supports flexible PRB exclusive and sharing policies. Guangzhou Metro can reserve a certain proportion of PRB to ensure the minimum bandwidth and maximum callable bandwidth for its private subway network, which provides isolation and certainty necessary for the private 5G network.

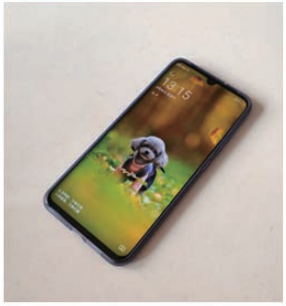
This practice is the first time that wireless PRB hard slicing has been successfully applied in the 5G SA environment. 5G-based AR+ face recognition is deployed for security application. A 4K HD camera is installed for passenger face capture, online automatic recognition and remote judgment. This improves the accuracy of troubleshooting and travel safety. The Guangzhou Canton Tower Station has also become a demonstration station for 5G Smart Metro in China.

5G+MEC Smart Factory Based on Industrial Precision Cloud Network

The combination of 5G and Industrial Internet

5G QCell

ZTE 5G CPE MC801A



ZTE Axon 10s

Fig. 1. Devices used by Guangzhou Metro.

will have great application potential and enable the manufacturing industry to transform digitally and even upgrade intelligently. The Yunnan Branch of China Mobile (Yunnan Mobile) recently joined hands with ZTE to create an industrial precision cloud network solution. With traffic offloaded locally by MEC, the solution enables Yunnan Shenhuo Aluminum Co to realize local management and operation of its network traffic, thus meeting the requirements of low delay and large bandwidth of video surveillance, mobile office, and on-site data collection and transmission in the industrial park. Different from the traditional centralized cloud computing, MEC integrates cloud computing, mobile computing, and wireless network functions, so that the cloud can deal with a large number of storage and computing problems of mobile devices in real time, and users can access different networks as required by customization. In addition to enterprise private and public networks, the solution realizes network isolation based on campus, which ensures the security and isolation of enterprise data.

Yunnan Mobile and ZTE will further assist Shenhuo Aluminum Co in building smart factories to achieve digital twin platforms, smart security, autonomous driving, logistics and asset management, environmental monitoring, and other innovative applications based on 5G, MEC, big data, IoT, and AI.

China's First E2E 5G Slicing and Intelligent Manufacturing

ZTE worked with the Zhejiang Branch of China Telecom (Zhejiang Telecom) to help Supcon Technology Group launch China's first 5G SA site and run a successful pre-commercial trial of "5G slicing+MEC+intelligent manufacturing" in September 2019, aiming to build a new 5G smart factory.

Supcon Technology Group, the largest supplier of automatic control solutions in China, needs to collect a large amount of data in production and and transmit it to the industrial internet platform. However, the traditional network restricts the backhaul effect of HD videos, which ultimately has an uncontrollable impact on data analysis, control and prediction.

In response to the above pain points, Zhejiang Telecom, ZTE and Supcon Technology Group jointly developed an integrated solution of "5G slicing+MEC+intelligent manufacturing" that can implement rapid deployment of machine visual slicing and fast backhaul of video streams by using key technologies such as slice stores, wireless slicing awareness, end-to-end slicing security isolation, dynamic slice migration, UPF moving to edge, and UPF offloading. These slices can reduce the latency, jitter, and packet loss rate of video data transmission, guarantee the quality of video transmission and improve the accuracy and timeliness of video analysis results.

The solution is applicable to wireless data collection and operation monitoring scenarios, allowing operators to avoid on-site processes in mobile and harsh environments, thereby reducing the labor intensity and security risks of operators. Industrial cameras and edge computing gateways are deployed on the production line to replace monitoring instruments. The industrial cameras take a video of the feed inlet and upload the stream to MEC through the uplink 5G slice. After calculating and analyzing the images, MEC automatically notifies the classifier and raises an alarm in case of any abnormal image. The solution can also be used in enterprise full-service data integration scenarios, such as visual analysis of the bearer flow, device data collection, personnel security management and remote device maintenance.

As a 5G pioneer, ZTE has a complete 5G SA end-to-end solution and an ecosystem covering 15 industries such as manufacturing, transportation, education, health care and finance. With the unprecedented development opportunities brought by the new infrastructure strategy, ZTE will work with operators and industry partners to build a new 5G precision cloud network that will enable digital transformation of the industry and create a promising future. ZTE TECHNOLOGIES

5G Toolkit: Steering 5G New Infrastructure into Fast Lane

Yan Haibo

Chief Engineer of Wireless AI Solution Planning, ZTE

With the announcement of the results of the second phase of 5G bidding by China's three major operators at the beginning of 2020, large-scale 5G deployment has been carried out across the country. The scale of nearly 500,000 base stations has quickly made China a hot spot for 5G networks. It has become the focus of operators to implement rapid 5G site commissioning, optimize basic coverage and establish market competitiveness. To meet the wave of 5G new infrastructure, ZTE has made plans in advance and launched a variety of intelligent tools for rapid deployment and optimization of quality 5G networks.

SON: Self-Configuration Self-Optimization for High Efficiency

Configuration and optimization of neighbor cells, ENDC X2/Xn, and PCI are the first step in 5G site commissioning. However, inefficient manual operation is very difficult to meet the requirements of large-scale site commissioning. ZTE has developed 5G self-organizing network (SON) that uses AI algorithm to identify problems, improve maintenance efficiency, and enrich maintenance means. It realizes intelligent identification, organization, orchestration and error correction of neighbor cells and links, and thus facilitates rapid 5G deployment.

When a 5G site is powered on and its links are set up, the SON module of UME monitors the link setup and self-configures its neighbor cells according to the imported neighbor cell planning table. After the self-configuration of neighbor cells is completed, the system will self-check whether ENDC X2/Xn interface links are established between 4G and 5G sites. If not, the system will automatically initiate the link establishment without manual operation. SON can self-optimize neighbor cell configuration errors as well as PCI conflicts and confusions that may exist in the network. At present, since a 5G terminal chip does not support 5G NCGI measurement, ZTE adopts the solution of discovering unknown PCI and engineering parameters via the air interface to determine NCGI of the target neighbor cell. Reasonable and accurate configuration of neighbor cells can be ensured by setting the distance threshold, the RSRP threshold of unknown PCI measurement, and the number of unknown PCI measurements. Based on the configuration of X2/Xn interfaces and neighbor cells, the system detects PCI conflicts and confusions. If there is any PCI conflict, the system will self-optimize the PCI conflict and reallocate PCIs for 5G-5G and 4G-5G neighbor cells.

At the 5G deployment site in Fujian, SON completes the commissioning of 100 sites in three miuites compared with 20 minutes for a single site in the traditional mode. Automatic monitoring ensures that data is configured correctly and the efficiency is increased a hundred times.

WNG: Automatic Drive Test for Easy Site Acceptance

Large-scale site commissioning will inevitably bring a lot of drive test acceptance. Traditionally, a single site acceptance test needs three persons in a group who carry a laptop, a GPS, a frequency sweeper, MOS meter and test terminal to collect data during the day and analyze data overtime at night. The testers have a large workload and low efficiency, which affects site acceptance and access to the network.

Wireless network guardian (WNG), a new tool in the 5G toolkit supplied by ZTE, is an automatic drive test solution based on cloud server and APP architecture (Fig. 1). It can automate the whole process of wireless data collection and network evaluation and analysis report output, making the site acceptance easy.

The WNG service analysis and processing system is deployed on the cloud server. Professionals can set test tasks remotely by logging in to the server through the client. The test items include parameter verification and cell performance verification. The system can provide standard templates, customize test items, and perform multi-task distribution. Now a site acceptance test can be easily started only with one person, one vehicle and one terminal. After receiving the task, the terminal automatically collects data and reports it in real time. The server automatically analyzes and processes the data, and outputs a test report after the test is completed. The report template can also be customized as required. Testers don't have to stay up late to make reports anymore.

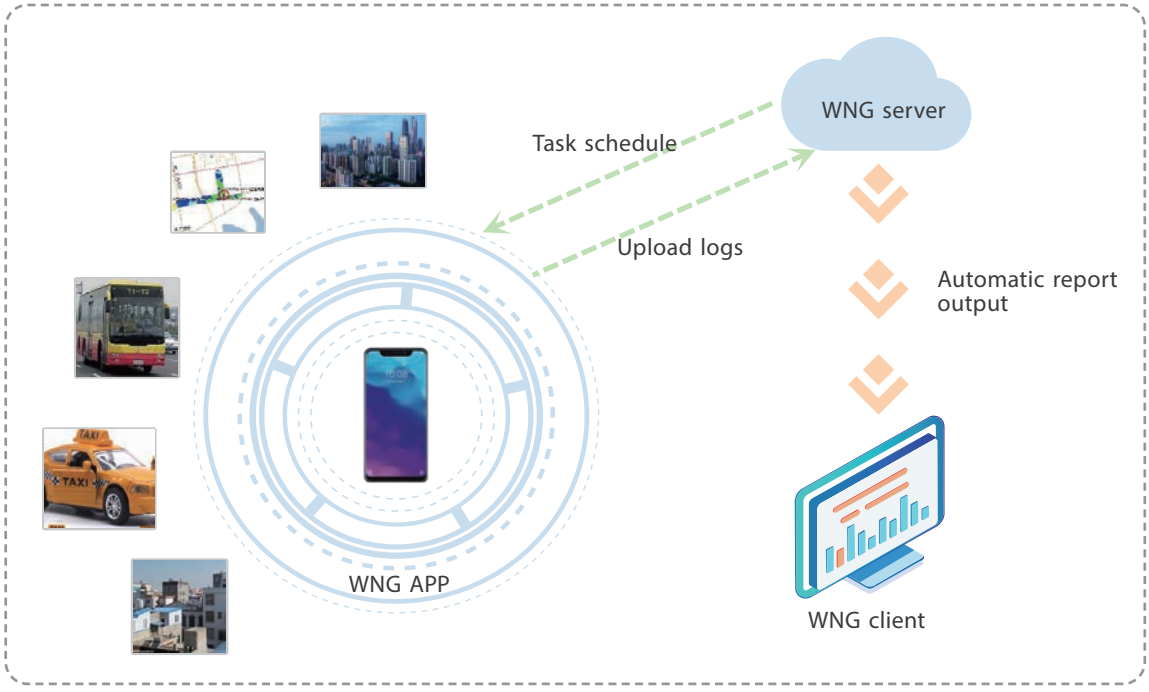


Fig. 1. WNG used for site acceptance.

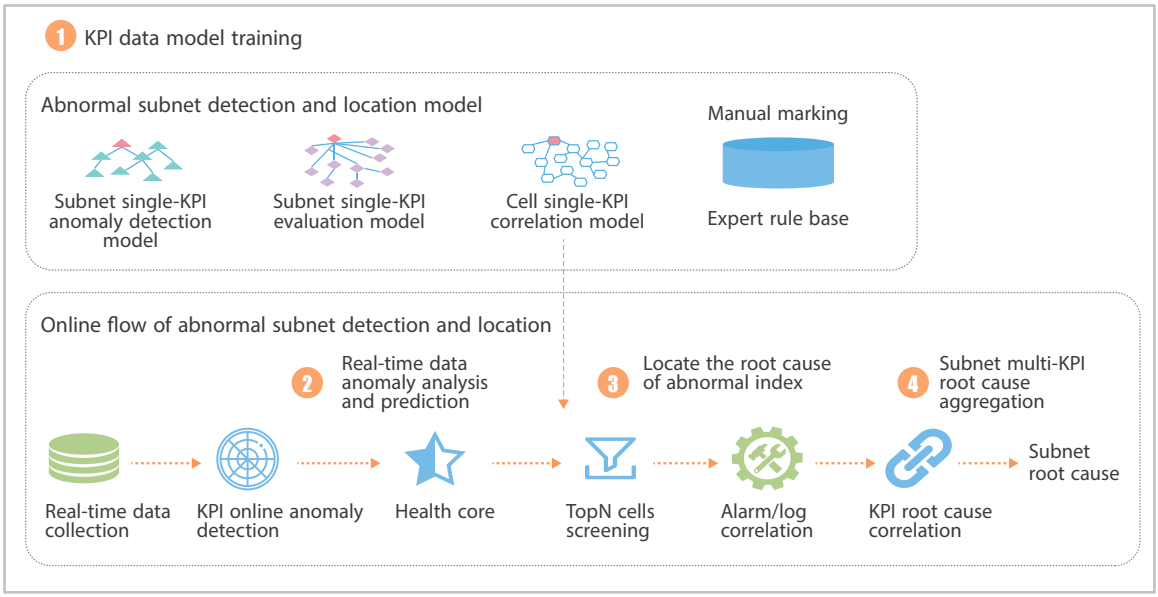


Fig. 2. Online inference service.

In China, more than 50 outfields have applied WNG as a single test tool for 5G sites. More 500 terminals are used in test task and more than 1000 reports are output every week. Compared with the traditional drive test mode, the number of personnel has been reduced by 60%, and the efficiency has been improved by 65%.

AAPC: Automatic Antenna Pattern Control for Effective Coverage Enhancement

Massive MIMO, one of the key 5G technologies, can effectively improve three-dimensional extended coverage and system capacity in complex scenarios by using large-scale array antennas and three-dimensional beamforming. Compared with the traditional antenna, Massive MIMO has more parameter adjustment dimensions, including horizontal beam-width, vertical beam-width, azimuth, down-tilt angle and the number of beams. Each dimension can be well adjusted by setting a reasonable step size. Theoretically, there are tens of thousands of possible antenna parameter weights for a cell. In a actual 5G network, it is almost impossible to perform manual multi-cell collaborative optimization and adjustment according to changes in the scenarios and services.

ZTE's automatic antenna pattern control (AAPC) adopts AI-based ant colony algorithm to optimize antenna weight groups based on the balance between optimization target and search time. Through simulation learning, the weight group with no obvious effect is abandoned. AAPC sets the maximum number of iterations to reduce the requirement of computing power and greatly reduce the search time for an optimal solution. It gives optimal weights according to different scenarios, user distribution and optimization targets. After the optimal weights are executed by NE, the optimization data is reported by UE to verify the effect, and the next optimization iteration will be performed. In case of KPI deterioration, the previous weight group will be returned directly. In field trials, the test verified that it used to take more than 40 man-days to manually optimize antenna weights, but now it takes only two man-days to complete the

optimization using AAPC, with high efficiency and good effect.

AI: Smart KPI Detection for Early Troubleshooting

KPI is a direct reflection of network quality. An KPI anomaly means that some failure may occur in the network. O&M engineers have to deal with hundreds of KPI changes and alarms every day. Many times they are exhausted and it is difficult for them to monitor KPIs accurately and quickly. It is often not until users complain that they find KPI faults and start the handling process. With the help of AI new technologies, ZTE's wireless intelligent O&M system combines machine learning (ML) and expert rules to implement automatic KPI anomaly detection and fault diagnosis in the network, which is equivalent to a 24-hour "network health monitoring and diagnosis instrument" that provides network doctors with analytical data and root cause diagnosis. The system introduces a time series clustering method based on structure feature to classify KPIs. For each KPI type, the appropriate time series model is selected to predict its normal baseline in the next time granularity. If the real-time measurement value of KPIs exceeds the baseline, it can be found in the first time granularity.

When the system detects a KPI fault such as a defined known fault, the system will make a comprehensive analysis based on the correlated alarms, operation logs, network topology and expert rule base, and give root cause judgement and troubleshooting suggestions (Fig. 2). When an unknown fault is detected, the ML-based diagnosis module will use the partial least square (PLS) regression algorithm to analyze and locate the root cause. Through the contribution analysis of possible causes, the root counter index at the top is found as the abnormal root cause.

During the field verification, when the success rate of LTE E-RAB setup of a subnet suddenly drops from 99.9% to 99.2%, the system will soon discover this anomaly and drill down to analyze the root cause and rapidly locate the eNodeB of ID 208203. It is found that the success rate index of a cell in the eNodeB drops to 0, which makes the corresponding network indexes fluctuate abnormally. Through the alarm correlation analysis, when the KPI is abnormal, the RRU in the cell fails and is out of service. It is concluded that the RRU fault leads to the abnormal KPI change, and the time for the whole fault location analysis is less than 10 minutes. But through manual analysis, it took an experienced engineer at least two hours to analyze KPIs through the network management system to correlate alarms and logs, and drill down to the TopN cell to find out the problem.

In the new infrastructure construction, 5G will become a new artery of social information flow and an accelerator for industrial transformation and economic development. It is also the common goal of operators and partners to build a 5G network with perfect coverage, high quality and leading services. Focusing on new infrastructure construction and long-term quality network operation, ZTE's 5G toolkit introduces new AI technologies to analyze the pain points encountered in network deployment, operation and optimization, improve the efficiency of 5G site commissioning and quickly optimize the network. The 5G toolkit is developed to steer 5G new infrastructure into the fast lane and help countries achieve their economic and strategic transformation. ZTE TECHNOLOGIES

Focusing on Value Creation and Empowering Industries Precisely

Source: Mobile World Live

5G speeds up in China this year, as manifested in many ways. By June 6, only one year after 5G became commercially available, there had been more than 250,000 5G base stations, 36 million 5G users, and nearly 60 million 5G handsets. It is widely recognized that with 5G driving new infrastructure construction in China, 80% of 5G application scenarios will emerge in vertical industries. It is estimated that there will be 8 billion IoT connections by 2025 in China, 10 times that of 5G subscriptions.

"A CAGR of 3% in the communication infrastructure drove that of 22.6% in the internet industry," said Mr. Xu Ziyang, CEO of ZTE Corporation, in a recent GSMA summit. Each investment in the communications industry can bring about more than five times that in other industries, fully displaying the multiplier effect of digital industries. In addition to pursuing better development, the ICT industry will fully empower traditional industries to accelerate their digital and intelligent transformation, improve cost efficiency, and facilitate agile innovations, thereby driving the upgrade of the industrial structure.

Mr. Xu believes that in the process of industrial digitalization, the only thing certain is uncertainty. New business models are more likely to emerge across industries, and enterprises have increasingly complicated requirements for cloud services. For example, industry customers need to manage with fragmented scenarios, and pursue heterogeneous collaboration, lower TCO, and higher security. Those concerns are still not properly addressed by the existing public cloud services, although such services have been used in a wide range of scenarios. As public cloud services are charged on demand, they can meet the needs of small and micro and start-up enterprises, as manifested by their low startup cost and quick results. However, for large and medium-sized enterprises and the small enterprises that have entered the high-speed growth phase, their focus changes from cost efficiency to customization and high security, availability, and controllability. In this

ZTE CEO Xu Ziyang

"In response to such booming 5G commercialization, the precision cloud networks are expected to sustain a harmonious ecosystem and boost business development. ZTE is willing to work with partners from all industries to create a bright future for the digital economy," said Mr. Xu.

case, the pain points of public cloud services will soon come to light, such as end-to-end SLA and the low flexibility of full-stack cloud. To lay a firm foundation for the digital transformation of industries, it is necessary to integrate networks with cloud services and finally realize cloud-network synergy.

ZTE has been committed to focusing on value creation and providing scenario-based services that can precisely meet customers' needs. Mr. Xu holds that the key is to identify and address the pain points of industry customers, and accelerate technology iteration accordingly, thereby rising to the uncertainties and helping industry customers seize opportunities in digital economy. ZTE proposes the precision cloud and network integration solution, where cloud on demand and network-cloud synergy are available based on the distributed precision cloud and deterministic precision network. Moreover, with easy O&M, global coordination, and end-to-end intrinsic security, telecom operators can offer more reliable services and better user experience.

Distributed Precision Cloud

Mr. Xu believes that public cloud services may fail to meet the customers' needs, and PaaS may lack flexibility or individuation. To attract industry customers, operators need to focus more precisely on application scenarios of customers, so as to unveil their true pain points, solve problems with differentiated solutions, and create value through precise services to achieve a win-win situation. In terms of operations, differentiated and customized services involve more explorations, including lightweight startup, agile iteration, and low startup costs.

Mr. Xu also highlights the features of the distributed precision cloud. First, homologous technology stack and on-demand menu. The cloud has a JAVA-like compatible TECS Cloud Suite, which enables full-scenario cloud and a cloud-native technology stack, and supports AI, big data, and a dual-core engine. By configuring the required computing power and throughput, enterprises are able to deploy their systems on demand rapidly.

Second, low startup cost and agile innovations. The cloud supports infinite expansion and can be deployed with ultra-lightweight startup. For example, the basic embedded edge involves only one single node, and lightweight pool edge can start from 2 nodes. The cloud also enables innovation at one node and replication throughout the network, and supports agile service delivery, cloud agnostic migration, and scale-in/out.

Cloud computing, as a part of IT infrastructure, has been highly recognized in the industry. Operators have been deploying cloud services to meet their needs. Against such a background, ZTE has mapped out the path of evolution from public cloud to precision cloud. Mr. Xu notes that with some changes in the public cloud, we can provide more precise cloud services. First, "addition" on the IaaS layer. That is, to enhance network components by adding the service awareness, traffic offloading, and access mode selection features, and enable hardware acceleration and CDN cloud-network synergy. Second, "deduction" on the PaaS layer. ZTE aims to provide simplified, agile, and basic versions of PaaS service packages to achieve different capability configurations, thereby providing highly customized services for enterprise customers. "Less is more. Too many functions could cause too many compromises and restrictions," Mr. Xu added.

Except for achieving the aforementioned goals, making changes to the public cloud is eventually to assist operators in exploring new business in industry markets.

Deterministic Precision Network

In addition, ZTE deeply understands that the most valuable and differentiated resources of operators are their networks. With deterministic precision networks, operators can make full use of their network resources to achieve network-cloud synergy and deliver elaborate, precise, and sustainable services to industry customers.

As Mr. Xu points out, only in this way can we achieve the best performance of each bit in the

network. He compares the operator's network to fertile soil, and some short-term business to a fast-growing tree—it grows fast but consumes so much water and fertilizer that the soil may lose fertility in just a few years. The loss far outweighs the gain. That is why ZTE strives to effectively allocate its resources to provide customized services for different enterprises through precise cloud and network synergy, and build a harmonious ecosystem, where sustainability of the operators' network business can be achieved.

Comprehensive Support

In the precision cloud-network solution, ZTE provides easy O&M, global coordination, and end-to-end intrinsic security. Global coordination, which includes cloud-network synergy, cloud-edge synergy, and edge-edge synergy, enables adjustment and allocation of resources on demand, and cloud agnostic migration and scale-in/out. Easy maintenance allows IT departments to customize and manage the cloud with one click. They can handle complex changes and requests as easily as they do on a private cloud. To achieve intrinsic security, ZTE aims to construct active defense and personalized security networks. By introducing the zero trust architecture, ZTE strives to provide enterprises with ultimate network security, data security, and user safety. ZTE also tailors end-to-end security solutions for different industry customers.

Practice in and outside ZTE

Before proposing the precision cloud-network integration solution, ZTE has grasped the strategic opportunities brought by the extensive deployment of 5G, which drives the development of industry markets. ZTE keeps making improvement in the process of its digital transformation. In addition, the company keeps exploring its 5G application practices in different industry scenarios, and works with operators and industry-leading enterprises to continuously improve its solutions.

According to Mr. Xu, ZTE aims to be an ultimate cloudified company. It has started digital transformation in the R&D field years ago. Currently, ZTE has been upgrading and rebuilding its production system based on precision cloud and network. With such components as the private cloud, public cloud, business middle platform, data middle platform, AI middle platform, and orchestration center, ZTE has built an agile combat module for the front line, thus improving production efficiency, discovering business opportunities, and offering timely services to customers. Moreover, with iCenter, a corporate digital system, ZTE achieves mobile office and paperless office, enabling its employees to work from everywhere, even in customers' offices. Now ZTE aims to use AI technologies for smart online operation to tackle the uncertainties brought by future business.

"In industry-level practices, we have built and customized precision cloud networks together with our partners to improve production efficiency through digitalization," said Mr. Xu. For example, in the education industry, ZTE works with New Oriental to provide education resources beyond the limits of time and space, with an aim to channel the teaching resources to every corner of the country. In the media industry, ZTE joins hands with Xinhua News Agency to realize face-to-face communication through holographic display and set the stage for everyone everywhere. In the manufacturing industry, ZTE teams up with SANY to build all-digital construction sites, aiming to guarantee unceasing machine operation and the highest efficiency. In the healthcare sector, ZTE works with Neusoft Medical to help patients race against time. ZTE also supports SUPCON in ensuring more stable output of quality products. ZTE TECHNOLOGIES

China Mobile Pilots 5G in Guangzhou

Liu Min

Branding Director of ZTE RAN Products

Guangzhou is leading the 5G development in China. China Mobile and ZTE launched the world's first pre-commercial 5G NR in Guangzhou University City in 2017, which became an important milestone in China's 5G development. The banner "4G changes life, 5G changes society" hanging under the 5G site has become an impressive slogan in the 5G era. China Mobile and ZTE made the world's first 5G call on the 2.6 GHz band through a commercial terminal under the landmark of Guangzhou Tower in 2019. The large-scale 5G deployment over the 2.6 GHz band is booming now.

Guangzhou stood out among many cities in 2020, becoming the city with the largest number of superb grids for China Mobile and among the top 10 excellent cities in 5G. In April 2020, Guangzhou Mobile, ZTE, and more than 20 benchmarking enterprises and institutions in Guangzhou, kicked off a gala of jointly building the "5G Pilot City" in Guangzhou, and released the world's first subway 5G slicing network system, which attracted widespread attention.

Today, Guangzhou is leading in both 5G industry applications and network quality, striving to be the leading city in the 5G wave.

5G Transportation Demonstration City

5G industry applications are flourishing

in Guangzhou, among which the most representative one can be "5G transportation demonstration". In addition to the released smart subway applications, Guangzhou Mobile, ZTE, China Railway Guangzhou Group, Guangzhou Metro, Bus Group, Guangzhou Automobile Group, and Road Administration have made in-depth explorations on smart transportation applications and enterprise digital transformation. This not only improves the management of Guangzhou transportation system and the operation efficiency of related enterprises, but also provides convenient travel services for citizens and tourists.

First 5G Smart High-Speed Railway

Guangzhou Railway Group takes the lead in realizing 5G application innovations in three aspects of high-speed railway (HSR). It uses the first 5G HD smart eye that can detect whether the components on the bottom of HSR carriage are detached or deformed. Through the 5G network, the conventional work of two people in one hour can be replaced by an industrial camera and machine vision in two minutes, and the angle is more accurate and efficient. It adopts the first 5G HSR tele-eye to transmit high-definition video of road conditions beyond the line of sight to the driver in real time, so that the driver can make reasonable driving measures such as deceleration or braking in time, so as to reserve sufficient rescue time for the safety of life and property. It employs the first 5G HSR massive driving data auto-dump to save tedious manual operations such as traditional wired transmission and mobile hard disk copy and greatly improve transmission efficiency.

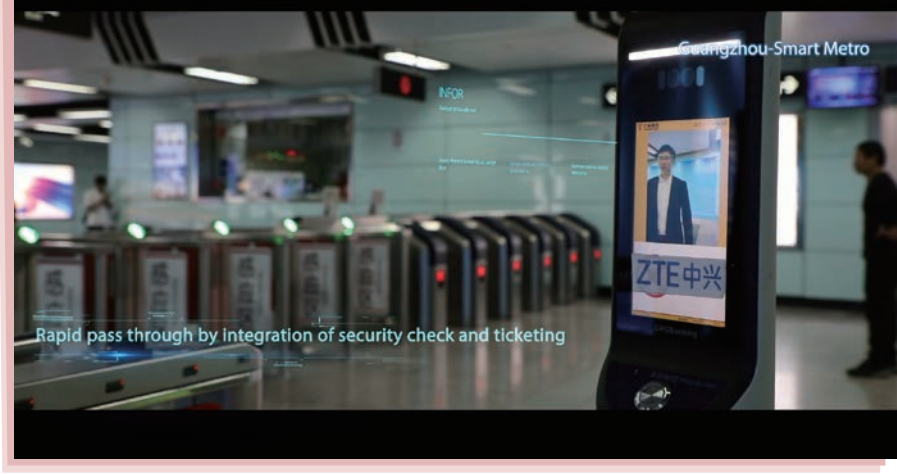
First 5G SA Hard-Slicing Subway

The first 5G SA hard-slicing applied in Guangzhou Tower Metro Station has realized full-scene intelligent subway management, which has greatly improved security and operation efficiency while reducing the implementation cost. The 5G-based AR+ face recognition capability is deployed in the subway, and 4K UHD cameras are installed at security machines or security gates for automatic face capture, automatic online recognition, and remote research, so as to improve the accuracy of identifying dangerous factors and enhance travel security of passengers. Moreover, network slicing can ensure that the whole process of data collection, transmission, and processing in the smart subway service is completed in the 5G private subway network and isolated from ordinary 5G data services. This ensures the privacy and security of user data.

First 5G BRT Intelligent Dispatching System

The bus rapid transit (BRT) system is the first in China to provide 5G coverage. It supports 20 application functions including fast operation scheduling, rapid bus traffic report, real-time panoramic video surveillance, and safe driving pre-warning. According to the statistics provided by Guangzhou Bus Group, the intelligent scheduling and data screening of bus services have saved 10% public traffic capacity, significantly improving the turnover efficiency of bus resources. The Bus Group has

Guangzhou smart Metro with AR security



also launched a "Guangzhou Traffic + Xingxuntong" guide service, providing optimal travel service for more than 8 million users. Through the 5G network, passengers can check whether the bus has seats and whether it is crowded, and can avoid crowds during the epidemic.

Leading 5G Intelligent Network-Based Driving

5G remote synchronous driving has been implemented. Through the 5G network, vehicle driving data is uploaded in real time, and HD videos are back-hauled in real time and synchronized to the instruments and meters in the remote control room for display.

First 5G Smart Road Administration Inspection

Nansha Bridge has been the world's first extra-large bridge with full 5G coverage. The bridge has realized China's first smart inspection of 5G road administration vehicles and 5G drones, being truly "connected, accessible, visible, and commanding". This completely improves security and emergency rescue capabilities.

Eight New Sights of Guangzhou with 5G Dual Gigabit Networks

If 5G industrial applications are a thriving spring forest, 5G network will be the foundation of their survival. Only with the deep-rooted and well-developed 5G infrastructure network can various applications flourish in smart cities. Through the point-line-plane multi-dimensional coverage, only with a deep-rooted 5G infrastructure and a well-developed root system can there be a flourishing of various applications of Smart City. Through multi-dimensional coverage, Guangzhou Mobile and ZTE have built a 3D seamless 5G network that can easily achieve stable 5G connectivity and excellent experience.

The 5G network has brought new life to this ancient Guangzhou. The combination of leading technology and natural landscape has made possible eight new sights of Guangzhou with 5G dual gigabit networks available everywhere on bridges, in cars, and from indoor to outdoor.

Pearl River New Town

As a national central business district (CBD), Pearl River New Town of Guangzhou has the densest skyscraper complex of over 300 meters in China. To meet the coverage needs of these skyscrapers, Guangzhou Mobile and ZTE proposed an innovative 5G 3D 1+X vertical coverage solution. It has been verified that the vertical coverage can be increased by 30%, the access capacity 30%, and the service capacity 5%. Its lean beam transmission can also reduce equipment energy consumption by 10%, achieving super 5G coverage scenario.

University City

University City, also known as South China's Silicon Valley, is the birthplace of Guangzhou 5G, where the world's first 5G NR is built. Through the 2.6G/4.9G dual-band coverage, a 5G network is built with the peak traffic of over 4 Gbps that can withstand the tide impact of all users, bringing them unlimited freedom of communication and exploration.

Beijing Road

Beijing Road is a living fossil of Lingnan culture in Guangzhou. It is a prosperous market for more than a thousand years, with narrow streets and large flow of people. Its average daily passenger flow reaches 400,000, with a peak of one million. Large-capacity macro cells, micro cells and pico cells are used together to fully meet 5G coverage and capacity needs of the high-density areas. During the Asian International Food Festival, citizens and tourists at the scene enjoyed a lot of food, while foodie friends far away could

feast their eyes on 5G HD live streaming.

Pearl River

Along the Pearl River there are wide roads on one side and tall buildings on the other. To meet outdoor and indoor coverage needs, industry-leading macro base station with a high power of 320W and a large bandwidth of 160M is used to provide wide coverage and large capacity. This helps to create an outdoor super grid with an average rate exceeding gigabit, while taking into account the penetration and extension of indoor coverage.

University City

Huanan Express

Huanan Express runs through the north and south of Guangzhou, and the traffic flows all day long, just like the non-stop pace of Guangzhou's development. 5G base stations at the roadside adopt Doppler shift compensation and super cell technologies to ensure a gigabit high-speed experience. The 5G network makes it possible to connect quickly and seamlessly in Guangzhou.

Nansha Bridge

Nansha Bridge is the first super project in Guangdong-Hong Kong-Macao Greater Bay Area, and also the world's first 5G bridge with full coverage. The 5G network overcomes a series of difficulties such as large inter-site distance, strong wind, salty environment, and sea-surface mirror interference. On the day the bridge was opened, Guangzhou Mobile and ZTE jointly demonstrated an intelligent inspection of China's first 5G road administration, which provided an example for intelligent security and emergency support.

Baiyun International Airport

Baiyun International Airport is one of three major aviation hubs in China, with an annual passenger throughput of more than 70 million, which is a typical high-value high-density indoor scenario. 5G QCell is small and exquisite for 5G indoor coverage. It is not only a landscape overhead, but also an expert in 5G indoor coverage. With 5G QCell, passengers can enjoy the time of waiting for airport pick-up, online HD video playing, cloud VR and cloud games. They can connect to the web as they wish.

China Mobile's Skyscraper

China Mobile's skycraper, Guangzhou Information Building, is located in the Pazhou West District where there are many first-class office buildings. In the Guangzhou Information Building, Guangzhou Mobile and ZTE use innovative indoor distributed antenna system (DAS) for smooth 5G upgrade, solving the traditional bottleneck of indoor distribution performance. According to the test, the downlink rate can reach 1.2 Gbps at a bandwidth of 100M, with an average downlink rate increased by 35% and an average uplink rate increased by 27%.

Now is the time for 5G, and Guangzhou welcomes you to experience it. Guangzhou is moving forward bravely on the road of leading and developing a smart city and a wise life. Guangzhou Mobile, ZTE, and all partners of Guangzhou 5G ecosystem will continue to drive innovation, accelerate the digital transformation of various industries, and promote sustainable urban development. They will work together to make everyone feel the warmth of 5G and jointly depict a bright future of 5G city. ZTE TECHNOLOGIES

ZTE Assists China Mobile to Deploy World's Largest 5G SA Core Network

Liu Rui

Director of Core Network Product Planning at ZTE

A Call for Quick 5G SA Implementation

2020 marks the beginning of commercial use of 5G SA around the world. It is a key year in which the deep integration of 5G with various industries will reap substantial results. This is based on three observations. First, with the freeze of 3GPP Release 16 specifications, the "5G+industry" orientation is further reinforced, which will accelerate the 5G construction progress, expand 5G application scenarios, and promote the transformation and upgrade of traditional industries. Second, various industries have an urgent need for intelligent digital transformation with 5G network. Third, operators are beginning to cultivate many new growth points along with 5G SA commercialization this year. These all underline the need for a high-quality, powerful 5G SA core network.

The World's Largest 5G SA Core Network

The fragmented vertical industry market with differentiated service requirements makes the 5G market uncertain, which needs to be encountered with the certainty in 5G. Subsequently, China Mobile employs ZTE's Common Core+ solution to build a precise 5G network to make full use of its comprehensive network resources, accurately differentiate between customers' features, accurately allocate network resources to different users, and give full play to every bit in the pipeline. In China Mobile's 2020 centralized procurement of new 5G SA core network equipment, ZTE has won the bid of 12 provinces in six regions for the public-oriented network, and secured the bid for 35% shares in 31 provinces for the industry-oriented network. Once completed, the project will become the world's largest 5G SA network. It is another breakthrough for ZTE in China Mobile's market after it won the bids for China Mobile's NFV phase-1 project and UDM project.

ZTE Showing Powerful Technical Strength During Tests

From 2015 to 2020, ZTE has been continuously improving its solutions, arranging exchanges, and testing project items. Before the results for the centralized procurement were announced, China Mobile had conducted meticulous solution validation and strict technical verification. ZTE demonstrated outstanding performance with its inherent advantages such as rapid network construction, localized services, long-term support, but more importantly, with its strong E2E capabilities. For large-scale commercial

5G deployment to succeed in 2020, China Mobile started large-scale 5G core network tests in September 2019, covering voice (EPS fallback, VoNR), charging, roaming, interoperation, performance, slicing, security and interoperability. The number of test cases for a single vendor reached 3,200 and the results were directly used for reference in centralized procurement. ZTE has always been in the first echelon during the tests of China Mobile. For example, in August 2019, ZTE was the first to successfully complete large-capacity 5G core network data forwarding and equipment performance verification in the lab of China Mobile Research Institute. ZTE's 5G core network system, based on the standard traffic model of China Mobile's 5G core network, was successfully tested and accepted with 2 million users, 4 million sessions and 200 Gbps traffic. In the second half of 2019, during the 5G O&M test of China Mobile, ZTE ranked No. 1 in test progress and pass ratio.

In August 2020, several months after winning the bid, ZTE completed the to customer (To C) first-office application (FOA) test of China Mobile's SA 5GC project, fully verifying basic functions, network performance and network security of the 5GC network, which lays the foundation for the large-scale commercial use of the 5GC network. ZTE was the first vendor to obtain the network access license of all NFs in the To C network.

Joint Promotion of 5G Innovations

China Mobile takes the lead in the world in 5G SA commercialization progress and scale, and it adopts regional construction and multi-layer distributed UPF deployment. With ZTE's Common Core+ solution, China Mobile can enable network reconstruction based on SDN/NFV, agile network functions based on SBA and cloud-native architecture, vertical industry development based on E2E network slicing technology, and network operation and maintenance automation through the AIC tool to flexibly deal with various network construction problems and challenges.

To realize fast 5G SA deployment, China Mobile adopts ZTE's patented interworking function (IWF) provisioning-free solution. In the early stage of 5G deployment, 4G user data is not cut over to 5G, and there is no need for 4G network reconstruction. Users can still enjoy 5G high-bandwidth services without changing their cards or numbers. In China Mobile's bidding for UDM/UDR/IWF equipment, ZTE won a market share of nearly 50%.

With respect to service innovation, China Mobile has been working closely with ZTE to guide and promote the establishment of international 5G messaging standards, and takes the lead in the formulation of Chinese industry standards. On June 30, 2020, China Mobile joined hands with ZTE to complete the 5G messaging service cutover of its southeastern region (Zhejiang Province), making the southeastern region the first commercial office for 5G messages in China. This also marks the official commercial use of 5G messages in China. Since February 2020, ZTE, together with Zhejiang Branch of China Mobile, has reached several milestones. With respect to the construction of 5G messaging platform, ZTE took the lead in four aspects: the first to make through the 5G first call, the first to send the 5G message, the first to migrate message services from the existing network, and the first to put 5G messages into commercial use. With respect to service operation, it promoted the establishment of the 5G messaging alliance and held the 5G messaging application developer competition, thus creating a new 5G messaging ecosystem with industry partners.

Summary

With the acceleration of the new infrastructure construction including 5G and industrial internet, ZTE has been actively involved in the deployments of operators' 5G infrastructure, and constantly scaled up its 5G production capacity. Meanwhile, it has strengthened cooperation with top industry players to promote digital transformation of energy, communication, finance, government affairs and other key industries. The construction and commercial use of 5G SA networks will spell the beginning of a new round of 5G innovations. In 2020 and beyond, it is expected that 5G will expand into many vertical fields to deliver on its promise. ZTE TECHNOLOGIES

TIM Brasil Ushers in a New Era of Fiber Optic Based on TITAN

Cai Jiesong

Fixed-Network Product Manager, ZTE

TIM Brasil is a subsidiary of Italian operator Telecom Italia in Brasil and the third largest operator in the country. Despite its big mobile business, TIM Brasil is a small player in the fixed broadband sector of Brazil. By Q1 2020, it had around 600,000 fixed broadband users, holding a 1.8% share and ranking fifth in the Brazilian market. Because of its sluggish growth in mobile business, TIM Brasil expected to make a difference in the fixed-network segment. It planned to transform into an integrated service operator by launching mobile-fixed packages to attract users and gain market share.

Fierce Competition Calls for GPON Rollout

TIM Brasil started to plan and build fixed broadband networks in 2012. It worked with ZTE to carry out ultra broadband (UBB) projects and build very high-speed digital subscriber line (VDSL) networks in Sao Paulo and Rio de Janeiro states that provided users with up to 70 Mbps broadband services.

With the development of high-definition videos, online shopping and online games, user demand for high bandwidth and low latency was going mainstream. To meet the growing demand, Brazilian operators kept introducing higher-bandwidth, lower-price broadband packages. TIM Brasil urgently needed to upgrade its broadband networks to get ahead in the intense competition.

TIM Brasil hoped to expand its broadband footprint from Sao Paulo and Rio de Janeiro states to the other states. A Gigabit passive optical network (GPON) has many advantages such as high bandwidth, high efficiency, wide coverage, and low maintenance cost. There were less than one million FTTH users throughout Brazil in 2016. Against this background, building GPON on a large scale became a strategic choice for TIM Brasil.

Customized Solution Improves User Experience

At the beginning of 2017, TIM Brasil launched its GPON project under the TIM LIVE brand name. In mid-2017, TIM Brasil invited public tenders for medium-sized optical line terminals (OLTs) used in

GPON construction, focusing on product maturity and network evolution capabilities. The tenders attracted the participation of the world's leading suppliers of fixed network equipment. After scoring top marks in TIM Brasil's technical and commercial evaluations, ZTE won the biggest share of the GPON project.

TIM Brasil required that OLTs have high reliability, support ring protection and L3 routing, and be capable of smooth evolution.

High Reliability

TITAN employs a distributed switching and forwarding mechanism based on router architecture. Its control and forwarding functions are independent of each other. The main control cards support active/standby redundancy at the control plane and load sharing at the forwarding plane. These characteristics make OLTs highly reliable.

Ring Protection

TIM Brasil adopts the ring topology in its fixed networks. Previously, its VDSL networks employed multiple spanning tree protocol (MSTP)-enabled ring protection, with recovery from a disconnection usually taking two to ten seconds. TIM Brazil hopes to shorten the recovery time of the GPON networks to millisecond levels, which poses high requirements for link fault detection as well as active/standby switching and load sharing after the fault. Through its support for the Ethernet ring protection switching (ERPS) protocol defined in ITU-T G. 8032, TITAN limits the disconnection recovery time to within 50 milliseconds, making the network more secure, stable and reliable.

L3 Routing

TIM Brasil requires that OLTs can flexibly adapt to multi-tenant scenarios, connect different services on demand, and enable the sharing of network resources with other operators. TITAN supports powerful L3 routing functions, including L3 virtual private network (VPN) and virtual extensible LAN (VXLAN). It can act as a remote module of the edge data center to be integrated into a network architecture that is centered on data centers (DC). TITAN supports perfect network slicing functions, allowing for slicing at three levels—user network interface (UNI), PON port or OLT.

Smooth Evolution

TIM Brasil attaches great importance to OLT evolution capabilities and hopes that TITAN will support network deployments and upgrades in the next five to ten years. As a new-generation optical access platform, TITAN provides a super-large system capacity four times as high as that of the current industry level, and is significantly ahead of competitors in terms of switching capability, backplane bandwidth and slot bandwidth. Because TITAN is a unified platform supporting multiple technologies including GPON, 10G PON, TWDM-PON and 100G/25G PON, it enables TIM Brasil to choose access technologies as needed, flexibly make network development plans, and perform long-term smooth network evolution. TITAN supports standard northbound interfaces including NETCONF/YANG and OpenFlow, which can be connected with software-defined network (SDN) controllers in DC to implement smooth evolution from optical access network to SDN.

The OLT provided by ZTE for TIM Brazil is ZXA10 C650 based on TITAN—ZTE's new-generation optical access platform. With such advantages as advanced technology, mature L3 functions, high reliability and low latency, the OLT meets the needs of TIM Brasil for optical access construction and development plan.

Moving into a New Era of Fiber Optic

TIM Brasil started deploying GPON networks in 2019. After ZXA10 C650 OLTs went live, they have been operating stably, which ensures steady growth of TIM Brasil's fixed broadband business. By the beginning of 2020, TIM Brasil had deployed more than 160 ZXA10 C650 OLTs and rapidly increased the number of fixed broadband users from 480,000 to 600,000. Based on the GPON networks, TIM Brasil launched its TIM Live Ultrafibra brand, providing users with broadband packages at speeds ranging from 60 Mbps to 2 Gbps as well as many HD videos and live sports such as FOX and Esporte Interativo. These services are favored by more and more high-end home and enterprise users, propelling TIM Brasil into the fast lane of broadband development. ZTE TECHNOLOGIES

To enable connectivity and trust everywhere