VIP Voice

AIS: Reinforcing Market
Leadership Through
5G Innovation

Expert Views

5G Private Networks as
a New Enabler of
Digital Economy

Special Topic

Intelligent & Simplified
5G Private Network

Cover Figure | *Wasit Wattanasap, EVP and Head of Nationwide Operation and Support Business Unit at AIS Thailand*

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AIS: Reinforcing
Market Leadership Through 5G Innovation

Reporter: Mao Junyong

Wasit Wattanasap, EVP and Head of Nationwide Operation and Support Business Unit at AIS

AIS, Thailand's largest mobile operator, is accelerating the deployment of the 5G network to boost the country's capabilities in the digital economy despite challenges arising from the pandemic. Wasit Wattanasap, EVP and Head of Nationwide Operation and Support Business Unit at AIS, talks about the company's growth strategy during the pandemic, way to 5G innovation, and the world's first 5G NR-DC test completed with Qualcomm and ZTE. There has been a stream of collaborations on 5G innovation between AIS and ZTE, and recently they have signed an agreement to to build the first high-level 5G network in Thailand.

What is AIS's growth strategy in consideration of the pandemic's effect?

We anticipated such a crisis at the beginning of the pandemic. Even when there was an emergency state and additional costs with the inflation, different measures have been put in place to allow us to maintain our leadership, such as:

- Reduce the impact on income. We maintain the strong growth of our mobile service business. Even when the revenue growth is lower with rising costs, we keep investing and expanding our network to provide a good user experience and help our customer during this crisis. We have also accelerated the generation of new revenues by growing the corporate customer business, home internet and other digital services, which compensates and helps deliver satisfactory operating results and would make the company stronger in the future.
- Prepare for network infrastructure upgrades for both mobile and fixed broadband services with continuous investments in order to support both general and corporate customers and respond to the digital transformation of different industrial sectors.

- Improve cost control and management by adopting a 100% digital process both within the organization and customer services, with careful consideration on operating costs and new investment planning to enhance quality at reasonable costs.
- Manage liquidity to be prepared for volatile situations that may come with the potential economic crisis.

AIS is developing the smart 5G network. How are you innovating during the implementation?

In fact, before the 5G auction took place in Thailand, AIS was the first in Thailand to test 5G bands with many different use cases. We had collaborated with many partners, including network/device vendors, technology solution providers, global telecom operators, education service providers, business partners to find use cases or innovative applications that are not only for commercial use, but would also bring big changes to the society. This will help usher the economy into the digital age and give Thailand more economic bargaining power.

In March, AIS, Qualcomm and ZTE announced the world's first 5G new radio dual connectivity (NR-DC) showcase for 2.6 GHz and 26 GHz. What kind of impact

AIS, Qualcomm and ZTE test the world's first 5G NR-DC in Thailand.

it will have on the company's business expansion as well as the country's digital landscape?

The main goal of AIS is to continue to develop the 5G smart network as a national infrastructure with an investment budget of 30–35 billion baht. As a licensee holding the most spectrum in low band, mid band, and high band or mmWave, which is outstanding for fast data transmission and low latency, we have never stopped deploying innovations to upgrade the network, including 5G NSA/SA, VoNR and 5G CA, to deliver a better experience for Thai people, which was our intention when we we joined the spectrum auction.

Continuing to work with global partners ZTE and Qualcomm to jointly test 5G NR-DC technology is a significant step forward. 5G frequency bands 2.6 GHz and 26 GHz are combined for the first time in the world, resulting in a wider signal transmission channel and low latency. With low latency, there could be a good user experience for consumers and future industrial applications such as online game streaming (Cloud Game), autonomous vehicle control as well as remote robot control that can be done in real time. Moreover, this test can

also support the development of new mobile chipsets in the future that will make the data transmission faster as well.

This is another advancement in the adoption of 5G mmWave for both commercial and industrial applications. And it reflects very well that AIS is the only service provider that has used its licensed spectrum of every waveband to support the growth of the business sector in various dimensions, including creating changes in the usage behavior of Thai consumers continuously and keeping up with the latest development of Qualcomm, the world's leading chipset provider. This ensures that the AIS 5G network will be ready to respond and support the use of various devices that support the 5G mmWave technology, which are being launched continuously. It is also a great opportunity to support business growth in various dimensions.

What will come next in terms of achievements in AIS's 5G roadmap? What role do you hope technology suppliers like ZTE will take on?

For the development of AIS 5G, the goal is to provide customers with the best network experience for every scenario, whether it is indoor use, data download/upload or even the services with mmWave frequency band, which AIS has the most spectrum resources available.

Therefore, in our roadmap we try to develop innovations for the ultimate customer experience.

We expect technology partners to help us to enhance the network experience as well as jointly develop the ecosystem to allow our customers to enjoy the technology. **ZTE TECHNOLOGIES**

Cai Jiannan
Director of ZTE
CCN ToB Product

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Product Planning

5G Private Networks as a New Enabler of Digital Economy

With the commercial use of 5G, the rapidly growing communications industry has begun to be deeply integrated with Industry 4.0, which brings about the intelligent era. In this process, a convenient, efficient and fast-deployed 5G private network becomes the key driving force for intelligent empowerment.

Setting Policies for 5G Private Network

Industry 4.0 and intelligent manufacturing are the cornerstones of staying competitive with major manufacturing countries, which have formulated their own digital development strategies.

In China, the integration of 5G and industrial Internet has become an important engine for the digital transformation of the economy. On November 16, 2021, China's Ministry of Industry and Information Technology issued the 14th Five-Year Plan for the development of the information and communications industry. The plan proposes that by 2025, a high-quality industrial internet network covering all regions and industries will be built, and a batch of 5G+ industrial internet benchmarks will be created.

In Germany, with the development of Industry 4.0, 5G has captured the attention of many large industrial enterprises. As early as 2019, industrial groups in Germany required the planning of 5G spectrum for the construction of enterprise networks. German telecom regulator (BNetzA) began awarding 5G private network licenses in the 3.7–3.8 GHz band in 2019, and then opened up the 24.25–27.5 GHz band (26 GHz band) on January 1, 2021. German Volkswagen, Lufthansa and Siemens have started to build out their own 5G private networks.

In Japan, the Ministry of Internal Affairs and Communications (MIC) released the Local 5G Implementation Guidelines on December 17, 2019, and began to accept applications for licenses to operate local 5G services. In 2020, the wireless spectrum resources that can be used for 5G private networks were expanded to allow more companies to use 5G networks.

In France, on March 17, 2022, the government and regulator Arcep announced that industrial players can apply for trial

spectrum in the 3.8–4.0 GHz band until the end of the year. Businesses in sectors such as manufacturing, logistics, energy, healthcare and smart city can apply to this initiative to trial different use cases.

The development of 5G private networks brings new opportunities to vertical industries, telecom operators, telecom equipment vendors, and industrial application service providers. Especially for large economies with high industrialization level and huge production scale, the active development of 5G private network services can promote the long-term development of their intelligent manufacturing strategies.

Industry-Wide Efforts to Develop 5G Private Network

With 5G empowering a growing list of vertical industries, the 5G private network solution industry is taking off with many players involved including operators, traditional telecom equipment makers, IT and cloud service providers, and industrial application integrators. Focusing on the 5G private network, operators in China have defined three major private network scenarios based on industry requirements (Fig. 1):

- **Virtual private network:** A dedicated private network based on 5G slicing.
- **Hybrid private network:** A hybrid network where the control plane is shared, and UPF/MEC is deployed on

the enterprise campus.
- **Independent private network:** Deploying dedicated 5GC at the enterprise edge, which is isolated from the public network, and using independent or shared wireless base stations as required.

Operators have defined flexible private network solutions. In addition to helping operators in providing private network solutions, equipment vendors have also proposed differentiated end-to-end solutions to meet industry requirements. In the process of joint exploration with industry partners, ZTE has launched an all-scenario private network solution to meet the differentiated network requirements of various industries.

Traditional telecom equipment vendors strive to provide customers with new solutions integrating network, computing and services in the ToB private network market. Cloud vendors that provide customers with fast and convenient private network solutions are a new emerging force in the private network solution market. Through the cloud, they can provide networking services and resources required by services or applications to customers in all the areas at any time. In addition, cloud vendors redefine the features of private network design, commissioning, maintenance, and charging from the perspective of users, changing private network from a carrier-grade network to

Fig. 1. Three typical 5G private network deployment modes of operators.
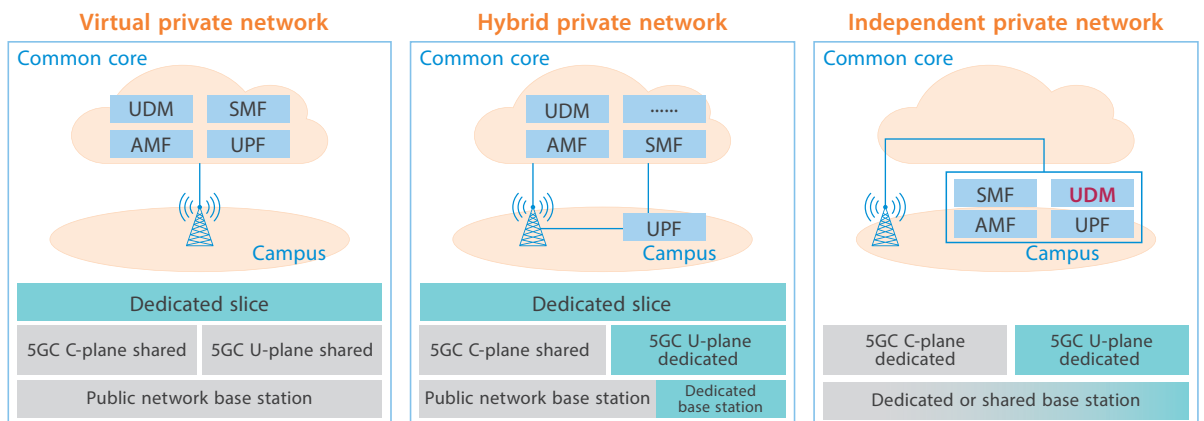
a consumer-grade application product.

Some industrial integrators work with traditional industrial network equipment manufacturers to enter the 5G private network market. However, facing an all-around competition from telecom equipment manufacturers, operators, and cloud vendors, industrial network equipment manufacturers will gradually lose their competitive advantages due to technical bottlenecks and other restrictions, and fall back to their inherent fields.

Since 2018, China has held four "Bloom Cup" 5G application contests. Rich experience has been accumulated in the planning, construction, O&M, and application innovation of 5G private network, especially in the fields of port, energy, mine, and industrial manufacturing. ZTE has won several first-class awards together with telecom operators and industrial customers in those "Bloom Cup" competitions.

ZTE's Private Network Solution

Capitalizing on its almost 40 years of experience in the communications industry, ZTE has launched a full-scenario private network solution including the following three aspects:

- **Flexible customization of network functions:** Customers can select network function components on demand to build private network solutions suitable for their industries.
- **Hardware in series:** To meet the requirements of different deployment environments, serialized hardware forms ranging from ultra-small bag, standard server to cloud cabinet or multi-rack are designed. Meanwhile, the dust-proof, explosion-proof and waterproof requirements of the equipment are also met.
- **Open operating environment:** The 5G private network can be deployed on mainstream public cloud or private cloud platforms. The network capability can also be opened to third-party applications to enable a concise and flexible deployment and operation environment.

ZTE's private network solution mainly provides customers with two product-based solutions: i5GC (industrial private network product series) and iCube (digital magic cube integrating the cloud, network, service and O&M).

ZTE i5GC helps customers build a simplified, professional, fast and highly reliable industrial private network. Its lightweight, low-cost, design-free, easy O&M, and one-click commissioning features make it easy for customers to purchase, build and maintain 5G private networks. For the mining industry, ZTE provides dedicated voice and data networks to meet all-round communication requirements for data and voice services. For the metallurgical industry, ZTE meets upload and download control requirements by providing big uplink and high reliability network solutions. For the transportation & port industries, ZTE provides dedicated and secure slicing solutions together with telecom operators, and meets the data security and network reliability requirements of customers through the UPF offloading capability. For industrial manufacturing, ZTE provides low-latency, high reliability, point-to-multipoint, and committable SLA network guarantees to help the industry become more sophisticated and intelligent.

ZTE iCube, with i5GC as its basic capability, integrates wireless, wired, transmission, MEC and third-party applications on demand to build the cloud network infrastructure. In addition to providing the network to users, iCube also provides dual-core cloud infrastructure driven by VMs and containers to provide the connectivity and computing power resources required by the industrial customers.

With the accelerated deployments of 5G private networks in the vertical fields, 5G network application is advancing from the periphery to the core of the industry. ZTE's private network solutions have been put into large-scale commercial use in both domestic and overseas markets, and have been piloted in key industries. ZTE will continue to work with operators and industrial customers to promote the intelligent development of all industries. **ZTE TECHNOLOGIES**

Standards for Private Network Enable 5G Innovation in Vertical Industries

Wang Xinhui, Vice President of ZTE

S tandardization is the key to the development of the 2C market in telecom industry to the trillion level today. In the 2B market with diverse needs, the primary questions and challenges facing the standardization are what features 5G private network needs, who will lead the standardization work for 5G private network, and how to set the standards for vertical industries.

There are usually two ways to achieve standardization. One is for traditional telecom standards organizations such as 3GPP and China Communications Standardization Association (CCSA) to formulate standards and specifications according to the different needs of the industry, and the other is to build a public technology platform where industry needs can be converged, innovated and extended to help establish an ecosystem and develop solutions recognized by industry users. The integration of 5G and industries is a gradual process. 5G applications in vertical industries in China have developed from trial to wide-spread adoption. The standardization of 5G private network in China has embarked on an innovative route that combines the above two ways.

Breaking Industry Barriers

CCSA established the Industrial Internet Special Task Group (ST8) in 2017, responsible for the standardization work of the whole industry chain of industrial Internet. ST8 aims to build a good industrial ecosystem, improve the independent innovation ability of industrial big data, and make manufacturing management more convenient and efficient. Since 2020, CCSA has launched the industry standardization work item "5G+ Industrial Internet Application Scenario and Technical Requirements" for specific industries in ST8.

At the end of 2019, CCSA also set up an ad hoc standard project team for 5G end-to-end network slicing to bridge the gaps in relative standards, specified the overall end-to-end architecture of 5G network slicing and capability requirements in related fields, and determined the standardization goal of promoting the application of 5G slicing in various vertical industries.

The Alliance of Industrial Internet (AII) reorganized the "Industrial Wireless Ad Hoc Group" into the "5G+ Industrial Internet Ad Hoc Group" in April 2021, dedicated to

> **The integration of 5G and industries is a gradual process. 5G applications in vertical industries in China have developed from trial to wide-spread adoption.**
>
> **Wang Xinhui**

bridging the gap between 5G and industries, gathering experts from ICT enterprises, verticals and research institutes to explore 5G technologies and network solutions that meet the needs of industrial deployment and use, and to seek replicable and scalable application models as well as business models for sustainable growth. By January 2022, the number of members in AII had reached 2,160.

The 5G Application Industry Array (5G AIA) based on building an integrated innovative platform for 5G applications converges the superior resource of telecom enterprises, solves common industrial technology problems, and achieves coordination of the 5G application industry chain. It published the white paper on "5G Industry Virtual Private Network Architecture" in July 2020, focusing on the problems in implementing 5G networks in vertical industries. According to the characteristics of different applications and scenarios in the industry, the white paper summarizes five key requirements such as cost reduction, diverse services, high security, self-operations, and system integration, which guide the standardization of 5G private WANs and LANs.

Coordination of Alliance and Industry Standards

AII and CCSA launched respectively the standardization of 5G private network in the industry sectors in 2020. The 5G private network standards they have specified cover industrial campus, power grid, mining industry, ports, high-end equipment manufacturing, aviation, cement and steel industry. The AII alliance standards are formulated quickly, and can serve as an important reference for the CCSA industry standards after the core parts are basically agreed. This mechanism leverages the advantage of AII to collect the professional advice of industry experts, ensure the recognition of 5G private network standards in the industry, achieve the coordination between the industry alliance and the communication standards organization, and shorten the time for CCSA to specify and release 5G private network industry standards. More industry standards will be launched under this mechanism in 2022, including the integration of 5G network with operational technology (OT), and 5G private network standards will be further promoted.

Guided by the "5G application 'sailing'

action plan (2021-2023)", 5G private network has achieved good results in technical standards and industry promotion. At the end of 2021, a total of 12281 entries from 31 provinces, municipalities, autonomous regions and special administrative regions in China were received in the fourth "Blossom Cup" 5G application contest. Comparing with 4289 entries received in the third contest, the number of entries in 2021 increased explosively, of which the number of entries for industrial Internet ranked first. This shows that 5G has been deeply involved in industry growth.

Evolution Trend of International Standards for Private Network

To meet diverse needs of industrial digitization and factory automation, 3GPP started "Vertical_LAN", a 5G network architecture work item for vertical industry from Rel-16, and implemented the standardization work. The Vertical_LAN work item includes three distinct 5G enablers for verticals: time sensitive networking (TSN), non-public networks (NPN) and 5G LAN-type services. For these three features, 3GPP has enhanced the relevant standard solutions in Rel-17 and has decided to further study and develop work items based on the three features in the 5G-Advanced phase of Rel-18 (Fig. 1).

Time-Sensitive Network (TSN)

The IEEE TSN specifications will integrate

deterministic and low-latency communication technologies in future factories. 5G time sensitive communication is a service that supports deterministic and synchronous communication with high reliability and availability. With enhanced evolution of Rel-16 TSN and Rel-17 industrial IoT (IIoT), the 5G system can integrate IEEE 802.1 TSN and provide time-sensitive communication as a bridge in TSN. Through network functions exposure and optimization of UE-UE time-sensitive communication, the 5G system supports enhanced deterministic applications.

The Rel-18 TSN features will be developed in the deterministic networking (DetNet) and 5G timing resiliency and TSC&URLLC enhancements (5TRS_URLLC) work items. Based on the work split between IETF DetNet WG and IEEE TSN, the DetNet work item studies how to enable deterministic QoS and time synchronization service by reusing the TSC framework defined in Rel-17 when placing the 5G system in the DetNet IP data plane network. The purpose of the 5TRS_URLLC work item is to study how to report the time synchronization status of the 5G system (such as the deviation of network timing sources of UTC and 5G systems) to UEs and third-party application functions (AFs), and how to enable AFs to request the time synchronization service in specific coverage areas and to request the highly reliable support and interworking with the TSN transport network.

Fig. 1. Evolution ▶ of 3GPP's work items for vertical industry.
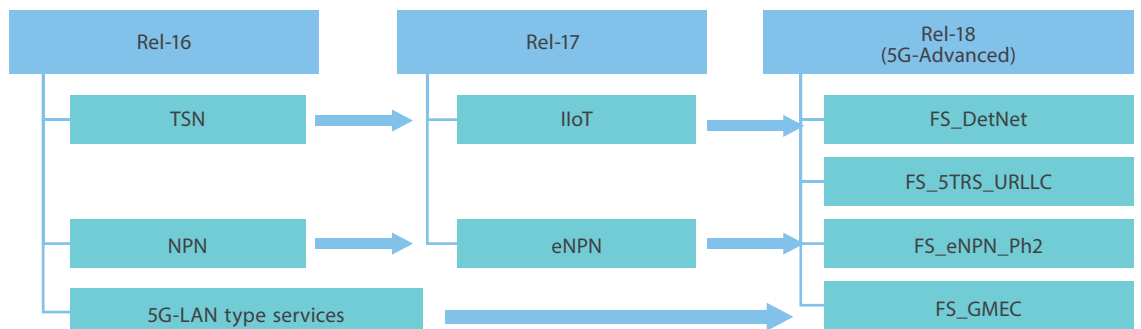
Non-Public Network (NPN)

NPN provides a 5G network solution specifically used for industry users, including stand-alone non-public network (SNPN) and public network integrated NPN (PNI-NPN). In the Rel-17 eNPN work item, SNPN is enhanced to support more NPN application scenarios through cooperation between different networks or entities. For example, access authorization is provided for the UE without local certificate or subscriptions, and IMS as well as video, imaging and audio for professional applications (VIAPA) scenarios are supported.

The Rel-18 eNPN_Ph2 work item further studies how to support mobility between SNPNs, how to access SNPN via non-3GPP, how to enable UE to discover, select, access the local hosting NPN and the localized services via the hosting NPN with proper authorization, and whether to enable NPN to support 5G proximity services.

5G LAN-Type Service

5G LAN-type service enables 5G network to provide services similar to LAN and VPN functions by improving 5G capabilities such as high performance, long-distance access, mobility, and security. The 5G LAN-type service can manage the group IDs, members, and group data of 5G virtual networks (VNs). The 5G VN group can be configured by the network administrator or dynamically managed by the third-party AF. In this way, the NEF is required to expose a set of services to manage the 5G VN group and 5G VN members. In addition, the 5G system supports routing optimization in the 5G LAN-type service scenario. When two UEs use the same user plane function (UPF), UE-UE communication can be achieved by directly enabling local data switching at the UPF without having to traverse the data network.

Rel-18 generic group management, exposure and communication enhancements (GMEC) is a work item for enhanced features of 5G LAN-type services. It intends to study how to enhance group attribute management and group status event reporting, enhance NEF exposure framework to enable capability exposure for provisioning of traffic characteristics and monitoring of performance characteristics applicable to each UE of a given group, enhance 5G VN group communication, and how to support group communication allowing UE to simultaneously send data to different groups, where each group has a different QoS policy, so as to meet the requirements of group communication scenarios in future factories.

Conclusion

Standardization is the commanding height of international economic, scientific and technological collaboration, and also the first move for enterprises, industries and equipment to "go abroad". China will accelerate the integration and improvement of 5G private network standards in 2022. ZTE remains committed to working with its industry partners, focusing on industry standardization organizations and alliances to make in-depth analysis on the characteristics of more industry requirements and find a balance between the versatility of 5G networks and meeting specific needs of various industries. In this way, standardization will become the "Quick Science Guide" and "Code for Improving Quality and Efficiency" for 5G to empower the industry, helping 5G promote the construction of global industrial Internet ecosystem. ZTE TECHNOLOGIES

Digital Twin, a Mirrored World

Tommy Bjorkberg
Director of CTO Group at ZTE

The Digital Twin concept was first published in 2002 by Dr Michael Grieves (then of the University of Michigan). Still, it was anticipated years earlier in David Gelernter's 1991 book, Mirror Worlds.

Long before the phrase, Digital Twin emerged, it was widely recognised that one of the first examples of a Digital Twin ever being used was by NASA during the Apollo 13 mission. The Apollo 13 mission to the moon didn't succeed due to a failure in an oxygen tank. That failure set off a chain of unforeseen and never even considered events, and over the space of 3 days, NASA engineers back on earth worked day and night to find a way to bring the astronauts back safely. NASA used sensor data and multiple simulators to evaluate the failure and extended a physical model of the vehicle to include digital components and real-time data in what is widely regarded as the first Digital Twin ever used. This first use of Digital Twin is also depicted in the movie Apollo 13.

But what is Digital Twin? Is it something we should be excited about, or is it just another blip in the technology landscape? Real-world objects have existed in digital form for almost as long as we have had computers. Simulations are widely used across industries, government and academia daily; computer games have become hyper-realistic, incorporating real-world locations and objects. The emergence of AR, VR and the Metaverse is becoming a melting pot between the physical & digital world. Considering all that, what is a Digital Twin, and how can it be useful.

What makes a Digital Twin a digital twin and not just a powerful model or simulation? A Digital Twin is personalised for a unique physical asset, process, or both. Digital Twin is the ability to take a virtual representation of the elements and the dynamics of real-world objects. It is much more than a simulation, more than a virtual replica of a real-world entity. It can connect the natural world and the virtual world by using real-time and near real-time data

from sensors, probes and databases.

The data can be either locally decentralised or stored centrally in the cloud. The inclusion of a vast amount of data relating to the real-world object sets a Digital Twin apart. Furthermore, the use of such data makes Digital Twin a living computational model instead of a static computational model, and a Digital Twin can be dynamically updated with data from its physical twin throughout its lifecycle. This ongoing relationship between the natural and virtual worlds sets Digital Twin apart from statistical and computational models or simulations. There are already multiple use cases for this relatively new technology, ranging from Manufacturing, Supply Chain to Healthcare & Retail, but let's take a closer look at how telcos can utilise Digital Twin. From a network perspective, telcos can use Digital Twin to help make accelerated decisions on where to invest their capital, resulting in an acceleration of the rate of investment and reducing the construction time of a network.

Digital Twin can also be used in network planning and simulations; for example, many regulations govern electromagnetic field emissions and radiating power. With the deployment of Massive MIMO and mmWave technology, phased array antennas have become a standard feature in wireless networks. As a result, we have to manage a much more complex radiating environment with multiple directional beams, beamforming and beam sweeping making power optimisation much more challenging. We can test and adjust radiating power levels using a Network Digital Twin containing data about the landscape, buildings, towers, network equipment, antennas, foliage, people, and traffic. We can even visually see what effect adjustments to radiating power will have on the real-world network. Doing so

enables us to find the best radiating power solution quickly and safely without adjusting and measuring in the physical network, which could negatively impact customers and even temporarily exceed regulations.

People could even have a Digital Twin of their homes, including information about building schematics and where pipes and electrical conduits are running. Also, information about appliances when they were purchased, warranty and repair information, how many times an appliance has been used, and instruction manuals are all in one digital place, constantly being kept up to date from sensors and smart home devices.

Today the Digital Twin Market is worth approximately USD 3-5 billion and is forecasted to grow by 10 times to almost USD 50 billion by 2026, making it one of the fastest-growing technologies. Digital Twins will become more advanced. The only limitation on how advanced a Digital Twin can become is the imagination of its creator and the amount of data and data sources being fed into the model.

Even though Digital Twin Models are getting more accurate, sharing or reusing models across applications or industries is far trickier. Like any technology that spans different vendors, sectors and use cases, integration and standardisation will play a key role in its future success. Organisations like the International Standards Organization (ISO) are already working on developing various standards for digital twins, and we can already find ecosystems of tools starting to emerge.

Digital Twin is not yet an off-the-shelf technology, and so far, we have only scratched the surface of this technology. However, one thing is clear the potential is endless, and Digital Twin technology will become an integral part of enabling us to achieve sustainability and enabling a circular economy. **ZTE TECHNOLOGIES**

5G Private Network 2.0 Era: Customization & Simplicity

Wang Jingfei

Director of Wireless ToB
Product Planning, ZTE

Zhang Fan

5G Core Network
Architect, ZTE

As of April 2022, China has built more than 1.5 million 5G base stations. There are 2400 "5G+ industrial Internet" projects, 30.72 million sets of industrial equipment connections and 225,000 industrial APPs across the country. After long-term exploration and accumulation, 5G has played an increasingly important role in industrial applications, providing a strong support for digital transformation of various industries.

ZTE, a global leader in 5G, has been actively exploring private network implementation combined with industry applications since the global commercial deployment of 5G networks. To verify the availability of 5G network to the industry, the early industry practice used the same hardware and technology as those in the ToC network, which was the era of private network 1.0. However, general-purpose 5G products and hardware cannot meet the requirements of enterprise users for deployment conditions, reliability, and overall cost. As a result, 5G private

networks have entered the 2.0 era, that is, the era of customized private networks.

In the private network 2.0 era, the growth of 5G networks has the following features.

Enhanced Adaptability to Network Scenarios

By cooperating with industry-leading enterprises, ZTE has developed scenario-based solutions to achieve rapid 5G promotion, covering more than 10 industries such as power, coal mines, manufacturing, ports, iron and steel, petrochemical, rail transit, supermarkets, hospitals, and campuses.

On the wireless side, ZTE has developed hardware devices such as high-frequency devices and intrinsically safe explosion-proof devices, innovatively proposed Qcell chain networking and pBridge-free direct

connection, and provided simplified edge computing NodeEngine, edge video gateways, and nomadic base stations.

On the core network side, ZTE provides a full range of lightweight 5G private core network products, including general iCube, compact iCube and single model i5GC. In the simplest scenario, a 2U server can be deployed with a 5G core network to provide a simplified 5G network with minimal space and energy consumption.

In terms of network operation and maintenance (O&M), ZTE's ToBeEasy solution provides one-stop integrated cloud-network O&M. The five-in-one network management helps to achieve efficient end-to-end cloud-network delivery, that is plug-and-play deployment in a lightweight manner, so that industry applications can be easily

viewed and managed. The enterprise users can operate and maintain wireless networks as they do with optical modems.

For private wireless network planning, ZTE has developed 5G private network solutions for specific scenarios in vertical industries, involving network requirements, planning, design, construction, maintenance and optimization. Their typical services include video backhaul, remote control, machine vision, cloud PLC and AGV, and are applied to electric power, mining, port, iron and steel, manufacturing, rail transit, supermarket, and chemical industry. Through joint practice with industry leaders, ZTE has accumulated experience and copied it to other enterprises to promote 5G applications and provide guidance for the replication and promotion of

subsequent private solutions.

Enhanced Network Access Capability

ZTE's private network 2.0 solution adds industry IMS (iIMS) capability on the basis of i5GC. With cloud-network cabinets as the carriers, the solution provides "data + voice" dual-engine private network. ZTE replicates and applies its experience in large-scale commercial use of VoNR in the ToC field to the ToB field, helping enterprise users achieve high-definition voice and video calls in the mining area. In this way, the underground 5G network is fully covered with data voice. In addition, ZTE can interconnect with third-party voice dispatching manufacturers to integrate 5G networks into private mine networks and accelerate the intelligent upgrade of mines.

By moving the lightweight i5GC and iIMS network to the exclusive campus (mining area), enterprise users can make voice calls using various types of terminals, including fixed and mobile terminals, and enjoy private network voice services such as internal short number interconnection, automatic or manual station services, and secondary traffic distribution. At the same time, the lightweight private iIMS can be connected to an operator's large IMS for interoperability between the private network number and the external large network number.

To address the pain point that enterprise users use a large number of commercial voice-centric terminals and are unable to access the network without IMS deployment, ZTE has launched an innovative AnyDevice solution in its 5G private network 2.0. The solution provides embedded proxy components, enhanced access engine and optimized authentication logic in i5GC, so that enterprise users can use any commercial terminal to access intranet ToB industry data, achieving zero perception access, zero hardware addition, and zero terminal restrictions. This greatly enhances application scenarios of the private network.

In the ToB scenario, the volume of uplink data traffic is much larger than that of downlink data traffic. ZTE has proposed an 1D3U interference coordination scheme, which allows users to flexibly configure the ratio of online time slots to offline timeslots to provide more uplink access capabilities. SuperMIMO can greatly improve the uplink capacity of multiple users in a unified area, and the total throughput can be increased by up to four times.

Enterprise users are more and more widely distributed, and they have the need for network connection whether in the far sea or at low altitude. ZTE's tailor-made ultra-far coverage products can cover up to 100 kilometers of the sea surface, providing network guarantee for fishing boats and aquaculture, and its 1+X coverage solution can offer three-dimensional coverage of the airspace below 300 meters, which provides the possibility for the promotion and application of dones.

Enhanced Network Determinacy

As 5G gradually penetrates into their core-layer services, industrial enterprises have increasingly high

requirements for deterministic 5G networks. An ultra-low latency and ultra-reliable deterministic 5G private network will continuously empower core industrial processes and improve production efficiency.

Time sensitive networking (TSN) and ultra-reliable low latency communications (URLLC) are key technologies of 5G empowering industrial control. ZTE has released the time promised communication (TPC) solution in its private network 2.0, which can provide a series of new capabilities and features based on 5G TSN, 5G LAN, URLLC and SLA precision control defined by 3GPP Release 16, as well as a new architecture for super wireless core network convergence. Through the end-to-end architecture innovation and scheduling optimization of the 5G system, the solution provides a deterministic and promised delay jitter to fundamentally guarantee precise industrial control for enterprises.

To meet the differentiated high reliability needs of the industry, ZTE takes the lead in grading network reliability in its private network 2.0 and provides a four-level high reliability mechanism.

- **Level-1 reliability:** Through the self-healing, regeneration, and migration mechanisms, local devices can be rapidly recovered when a fault occurs. This is applicable to scenarios where there is no high requirement for service interruption.
- **Level-2 reliability:** 1+1 hardware redundancy is adopted without a single point of failure. Servers, switches and firewalls are backed up with dual networks, dual planes and dual physical ports. This is applicable to most commercial private networks.
- **Level-3 reliability:** 1+1 hot standby and session-level synchronization are provided. When a fault occurs, the terminal will not be dropped and the service will not be interrupted.
- **Level-4 reliability:** 3GPP R16 URLLC end-to-end dual-PDU session redundancy, and frame replication and elimination for reliability (FRER) are provided. This is applicable to industry application scenarios that have high reliability requirements for end-to-end 5G systems.

Conclusion

With the deepening of the 5G-enabled industry, 5G ToB private network has entered a new stage, and the industry urgently needs a new network to meet its characteristics. 5G evolves from the public network 1.0 that provides basic connectivity to the new private network 2.0 era that provides scenario adaptability, enhanced network access capability, ultra-high bandwidth, wider coverage, enhanced network determinism, deterministic delay jitter, ultra-high reliability, and simplified local operation and maintenance.

ZTE is not only an important supplier of 5G network equipment, but also an active network service provider in the industrial digital transformation. It aims to provide the best private network and help the industry with full digital and intelligent transformation. In the face of diverse needs of thousands of industries, ZTE tries its best to offer customized and simplified solutions to accurately empower the industries. **ZTE TECHNOLOGIES**

CampSite with High Network, Cloud and Service Integration
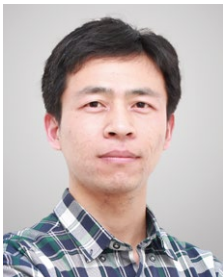
Liu Zhen

Director of ZTE RAN
Product Planning

As 5G services develop and 5G is deeply applied in B2B scenarios, traditional base station cannot meet the requirements of flexible movement, low delay, and flexible deployment in special scenarios. In response to these requirements, ZTE has reconstructed and upgraded the traditional base stations from three aspects: base station backhaul, traffic offloading, and auxiliary system, and has developed CampSite with high network, cloud and service integration, low cost and flexible deployment.

Application Scenarios

The main application scenarios of CampSite include emergency communication, e-sports competition, mine communication, B2B service demo and smart construction site.

- **Emergency communication:** After natural disasters such as floods, earthquakes, typhoons and landslides, the original power supply, backhaul and wireless communication equipment are damaged and communications are broken down. CampSite can quickly restore the mobile communications system. In addition, while meeting the needs of public network communication, NodeEngine can be chosen to connect the local emergency command system and send large-capacity images and videos to it. This not only ensures the security of emergency command data, but also saves backhaul bandwidth of the Donor gNB.

- **E-sports competition:** CampSite can be temporarily deployed at the competition venue, and NodeEngine is connected to the server used for competition. This can meet the requirements of large capacity and low latency in the e-sports competition.

- **Mine communication:** Geographical environments and services of the mine are diverse. The data related to vehicle scheduling, equipment data collection and video monitoring can be transmitted to the local server via NodeEngine. This reduces time delay and the requirement for backhaul bandwidth. Moreover, B2C users can access the internet via CampSite.

- **B2B service demo:** CampSite can be deployed in the enterprise for exploring 5G private services, and NodeEngine can be used to connect to the application server to study the specific 5G B2B application via a 5G live network.

- **Smart construction site:** CampSite is deployed at the construction site, and NodeEngine is connected to the local video monitoring system and remote control platform. The video monitoring system can detect dust, noise and running status of engineering vehicles in real time and identify violations such

as not wearing helmets. Unmanned vehicles can be operated remotely to ensure the safety of personnel.

CampSite Solution

CampSite reconstructs traditional base stations in terms of backhaul, local offloading and auxiliary system. The CampSite solution has a flexible backhaul solution and local offloading capability to meet the needs of users for low latency and no data out of the campus. CampSite also has flexible auxiliary system and is easy to move and deploy.

CampSite can provide services for both B2C and B2B users. B2C users can access the Internet via CampSite and the core network, while B2B users access the local server via CampSite and NodeEngine. The data flow of B2B users is locally offloaded, which reduces the latency while ensuring data security.

CampSite consists of four parts: wireless module, backhaul module, local offloading module and auxiliary system, as shown in Fig. 1.

Wireless Solution

Wireless module include baseband and RF units. The baseband unit is a general-purpose device. The RF unit can be flexibly configured with iMacro or Qcell according to the status of donor gNB and the location of CampSite deployment. It should be noted that when CPE relay is used for backhaul, the donor gNB and CampSite need to adopt inter-frequency networking to avoid serious interference.

Backhaul Solution

CampSite can adopt multiple backhaul solutions, such as fiber backhaul, Internet backhaul, CPE relay backhaul and satellite backhaul. Fiber backhaul and satellite backhaul are general backhaul solutions.

The 3GPP defines integrated access and backhaul (IAB) in R16. However, IAB is based on the physical separation of centralized
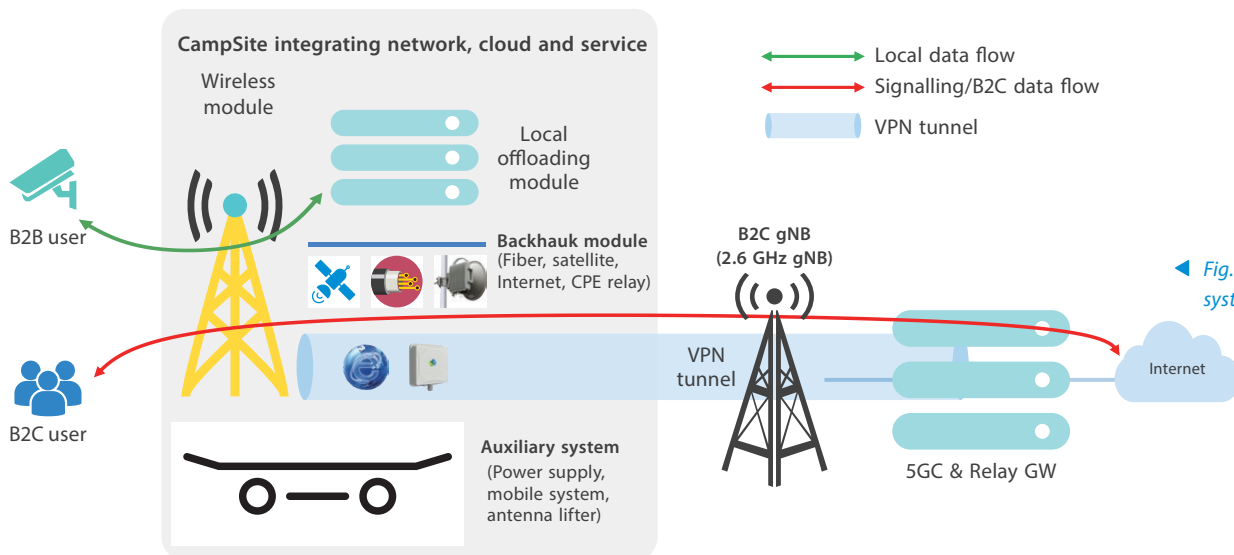
Fig. 1. CampSite system architecture.

unit (CU) and distributed unit (DU) and provides wireless backhaul between CU and DU via the F1 interface. This involves software changes and addtional new hardware, and the industrial chain is not yet mature. Currently, the CPE relay backhaul solution is adopted, with outdoor CPE used as backhaul equipment and a relay gateway (GW) deployed at the network side. A virtual private network (VPN) tunnel with the relay gateway is established at the CampSite side. The data among CPE, donor gNB and relay gateway is encapsulated in the VPN tunnel for transmission. The equipment that initiates the VPN tunnel establishment at the CampSite side can be CPE, CampSite or dedicated router. They build VPN tunnels on the same principle, and each has its own advantages.

The Internet backhaul solution is the same as CPE relay in backhaul principle. The establishment of VPN tunnels can be initiated via CampSite or dedicated router. When CampSite is deployed, different backhaul solutions are selected according to the actual scenario and onsite backhaul conditions. The wired backhaul is a preferred choice.

Local Offloading Solution

The NodeEngine solution means inserting a computing board into the baseband unit (BBU) slot, and moving the local offloading function to CampSite to meet user needs for low latency and no data out of the campus. At the same time, the computing and cloud platforms can also be integrated to meet the needs of capability developmen and local application deployment. NodeEngine has the advantages of low latency, local traffic offloading, plug-and-play, fast deployment, and on-demand expansion and co-sited O&M.

The computing power is moved to CampSite, and CampSite becomes the anchor point of data transmission. NodeEngine communicates with the application UE via the air interface, and interacts with the application server via the private network. With its unique ultra-low latency feature, NodeEngine can meet the service needs of low-latency interaction, remote control and video transmission. It can also provide B2B users with portal-level applications and differentiated 5G network QoS guarantee for different applications through visual management.

Auxiliary Solution

The traditional auxiliary system cannot meet the requirements of CampSite mobility and flexible deployment, so it needs to be reconstructed. The CampSite auxiliary solution highly integrates the outdoor cabinet, backhaul equipment, mobile vehicle and lifter, which saves space and is flexible to be applied and deployed.

Both main communication equipment and batteries can be installed in the outdoor cabinet, which can meet the need of power supply without alternating current (AC). In addition to its own moving wheels, the mobile vehicle also has its own stable legs. It can resist level-5 wind without fixing the foundation ground. The lifter is made of aluminum alloy and supports the automatic/manual lifting system. The maximum lifting height can be six meters to ensure the antenna is high enough to meet the requirements of network coverage and CPE backhaul.

CampSite with high network, cloud and service integration has a wide range of application scenarios. With the combination of 5G and B2B services, CampSite will be used in more fields. ZTE TECHNOLOGIES

Precise RAN 2.0: Enhancing E2E Deterministic Capabilities of 5G Private Network

5G deployment continues to accelerate worldwide, and the mission of 5G is to drive digital transformation of industries. Adapting 5G to industrial needs is key to the success of 5G, and also an enabler for transformation of operators.

2021 is the first year of commercialization of 5G industrial application. ZTE launched the 5G precise RAN solution at the beginning of 2021. This solution runs through precise planning, precise slicing, precise identification, precise scheduling, precise measurement and precise O&M, which enables 5G to shift from best effort to deterministic communication. After a year of practice, ZTE upgraded the precise RAN solution to 2.0 with a series of innovative enhancements addressing the pain points of the industry. These enhancements include: top-level private network design and template solutions for 10+ industries; more precise slice resource reservation; EdgeQoS providing intelligent, flexible and precise service guarantee; and the ToBeEasy system providing easy O&M of private networks. With the E2E deterministic capabilities enhancement, the precise RAN 2.0 solution enables a more efficient 5G private network (Fig. 1).

Precise Planning 2.0

In precise planning 1.0, B2C and B2B planning differ in the coverage design standard (from overall performance to a specified spot), requirement model (from one dimension to three dimensions), and wireless scenario (from assumed to specific). Precise planning 2.0 has made two major improvements:

- The B2B simulation and big data platforms support the dedicated B2B features.

The precise B2B network planning should be focused on single user and single service, while the traditional B2C network planning only on overall performance estimation. ZTE
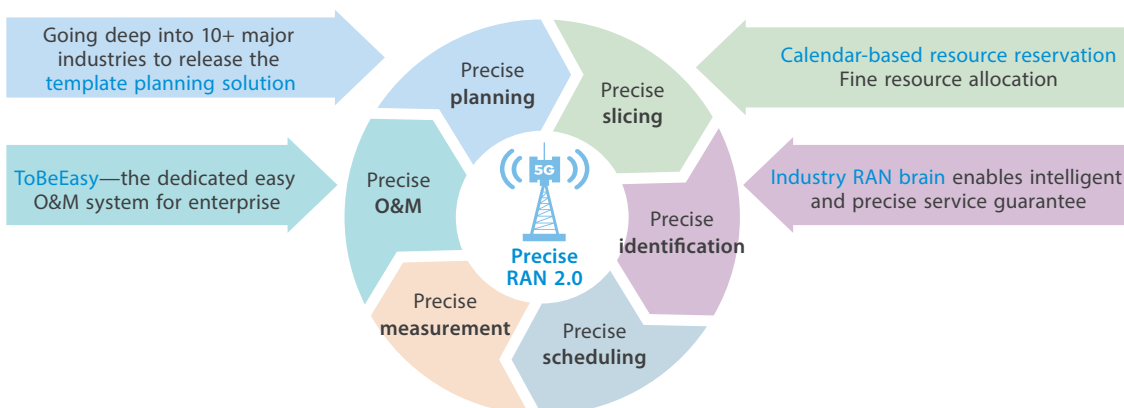
Fei Teng

Chief Engineer of ZTE B2B RAN Product Planning

Ni Yanzi

Director of ZTE RAN Product Solution

◀ Fig. 1. ZTE's precise RAN 2.0 solution.

has launched the simulation platform and big data platform to meet B2B planning requirements.

ZTE's global simulation platform supports simulation based on high-resolution (1–5m) electronic map and ray tracing model, indoor/outdoor collaborative simulation, and correction with measurement report (MR) or drive test data, and accurately predicts the network coverage. It also supports the construction of channel models, and the loading of user locations and tracks, and predicts the attainable rate of each terminal through a Monte Carlo simulation. The supported simulation scenarios include industrial parks, aviation coverage, drone inspection, sea coverage, and tunnels.

ZTE's big data platform can implement precise and intelligent network planning and service orchestration. The big data platform collects multi-dimensional network data, and predicts the grid-level network coverage and user throughput to quickly determine whether the network meets the B2B service requirements. If not, the platform could give suggestions for network enhancement.

● Top-level design of private networks for 10+ major industries

ZTE has accumulated extensive experience in 5G private network design. For each of the 10+ major industries, including power grid, coal mining, manufacturing, port, and steel-making, ZTE can provide a dedicated private network design, covering a series of innovative and customized products and technologies (e.g. cloud-network cabinet series, explosion-proof base stations, miniaturized BBU for rail transportation, QCell without pBridge, site-level computing engine NodeEngine, and CampSite solution for movable private network). And leveraging a series of enhanced capabilities of 5G such as large uplink, low latency, high reliability and high precision positioning, the private 5G solutions could be replicated in an industry.

Precise Slicing 2.0

Slice resource guarantee is the basis of service guarantee. Compared with slices with shared

resources, slices with reserved resources ensure that the service experience will not be affected under resource constraints, and they provide deterministic resources to guarantee the SLAs of B2B applications.

However, with the development of 5G in vertical industries, more and more private network slices need to be deployed; and the limited cell resources make it hard to reserve resources for all the slices. Precise slicing 2.0 supports calendar-based resource reservation, which means that the resource for slices can be allocated at different times to allow the deployment of more slices inside one cell. This significantly improves the network efficiency while guaranteeing the service experience, increasing the commercial competitiveness of a private network.

Precise Guarantee 2.0

Compared with the non-differentiated parameter setting and best-effort service of B2C, the B2B "slice +5QI" based scheduling could provide differentiated SLA guarantee. However, it is based on static and complicated service subscription and parameter configuration, and requires that the QoS subscription, SIM card, CPE and industrial equipment should be strictly bound, which means that any mismatch or change will affect the service guarantee, and any service addition/adjustment must be modified through the core network. Therefore, precise guarantee 2.0 incorporates the AI-based EdgeQoS to realize automatic service identification and precise closed-loop scheduling so as to achieve service guarantee easily.

Precise Identification

ZTE's EdgeQoS has innovatively introduced the AI-based intelligent service identification function to realize the dynamic identification of local services in parks, providing different applications in parks with the corresponding flow-level guarantees. In this way, only default

subscription is required, and SIM cards, CPEs, and industrial equipment can be matched freely. As long as services are started, the EdgeQoS will automatically analyze and recognize the services, which greatly simplifies operators' subscription flows and service deployment. The efficiency of industrial application deployment can be improved by more than 10 times.

Precise Scheduling

After the services are identified, the EdgeQoS matches them with the right steering and scheduling strategy, and performs closed-loop scheduling optimization based on the flow-level KPI measurement, guiding base stations to adjust radio parameters. And multi-dimensional enhancements are included in the above process:

- **Precise service identification and scheduling:** The EdgeQoS can identify the flow type and also the packet characteristics of a service, and then match the service with the corresponding resource scheduling function to improve the utilization efficiency of radio resources. For example, for video streaming service, the system can identify the I frame and P frame packets, and further identify their packet period, packet size and packet arrival time, so as to guide the base station to execute different scheduling strategies for I frame and P frame. Through such precise service identification and packet identification, a more refined service experience and network efficiency can be guaranteed.
- **Service orchestration to avoid I-frame collision:** Industrial applications include a large number of video services, such as video surveillance, machine vision, and video based remote control. Generally, video service streams are composed of I frames and P frames, and I frames require much higher throughput. When multiple video services are concurrent in the network, it is likely that multiple I frames are transmitted at the same time, that is, I frame collision occurs, and the instantaneous requirement for the network uplink bandwidth can reach several hundred

Mbps or even up to 1 Gbps. The EdgeQoS can recognize the I frame and orchestrate the video services orderly to avoid the I frame collision and efficiently utilize the network resource.

Precise O&M 2.0

To meet the O&M requirements of vertical industries, ZTE has launched the ToBeEasy solution, with its commissioning and management services as easy as IT service. It provides a lightweight, end-to-end, plug-and-play, intelligent and visual O&M platform for B2B, facilitating easy networking and intelligent O&M for operators and enterprise users.

- **Simplified network O&M:** ToBeEasy supports 5-in-1 multi-domain integrated system management, end-to-end automatic resource configuration, self-adaptation to service requirements, and more accurate fault location, improving O&M efficiency.
- **Enhanced service operation:** Services can be rapidly and automatically commissioned. Through one-click commissioning, the system automatically configures differentiated features and parameters. Proactive and intelligent risk prediction and fault delimiting and locating methods effectively guarantee the high reliability of enterprise connection services.
- **Service openness:** Open APIs are provided to meet the O&M requirements of enterprise applications. And flexible API orchestrations are supported to assist in low-code self-development and enable services on demand.

5G network is the strong base of industrial digitalization, and better serving vertical industries requires continuous improvement of 5G capabilities. Precise RAN 2.0 solution, developed based on ZTE's deep exploration of vertical industries, will help achieve a more efficient 5G private network, and allow 5G to be introduced into the core production domain, facilitating digital transformation of industries. **ZTE** **TECHNOLOGIES**

ToBeEasy: A New O&M Paradigm for ToB Industry

Zhang Maopeng

EMS Planning Manager of ZTE CCN Products

Zhang Bo

EMS Planning Manager of ZTE RAN Products

The 5G industry has a huge market space. In the context of stable competition in China and slow growth of ToC services, the revenue increase of ToB services has become a key to future development of operators. ToB users come from a wide variety of industries, and the traditional O&M mode centered on network equipment is difficult to meet E2E requirements of ToB industry users. Therefore, it is necessary to explore a new O&M paradigm.

ToB O&M Requirements

ToB networking features a variety of network topologies and devices, and enterprises are end users of the ToB network. Enterprise users expect the network to be stable and reliable, easy to operate and maintain, and applications-centered lightweight management to meet their needs of stable service operation. According to the survey of various ToB industries, rapid delivery, remote managed services, fast recovery and VIP terminal SLA guarantee have become their core O&M requirements.

With more and more industrial ToB applications, leveraging the advantages of 5G infrastructure to meet ToB O&M requirements is a new topic for operators and equipment vendors. Therefore, a turkey solution with a centralized and professional remote O&M system for operators and a smart and simplified O&M portal system for enterprise users is more suitable for operation and management of ToB 5G private networks.

ToBeEasy: Simplified O&M Solution

With decades of experience in professional O&M, ZTE has launched ToBeEasy, a simplified O&M solution based on the existing O&M solution, as shown in Fig. 1. ToBeEasy provides more choices and flexible ways for ToB applications.

ToBeEasy based on the concept of simplicity, centralization and intelligence improves the efficiency and intelligence of O&M, enables network delivery within hours, and provides active network guarantee. It uses a new cloud-native architecture and provides multi-level multi-dimensional O&M solutions for operators and enterprise users based on network management, centered on service management, and combined with atomic capability exposure. The ToBeEasy solution consists of three parts:

Fig. 1. ZTE's ToBeEasy simplified O&M solution. ▶

OSS/NMS/...
Operator's ToB O&M system

ZTE ToBeEasy™

UME R88
Centralized O&M system

IDOS R88
Enterprise-A's O&M portal

ZXeLMT
NE O&M

Plug and play

Enterprise-A's management system

Enterprise-A's campus

IDOS R88
Enterprise-B's O&M portal

ZXeLMT
NE O&M

Plug and play

Enterprise-B's management system

Enterprise-N's campus
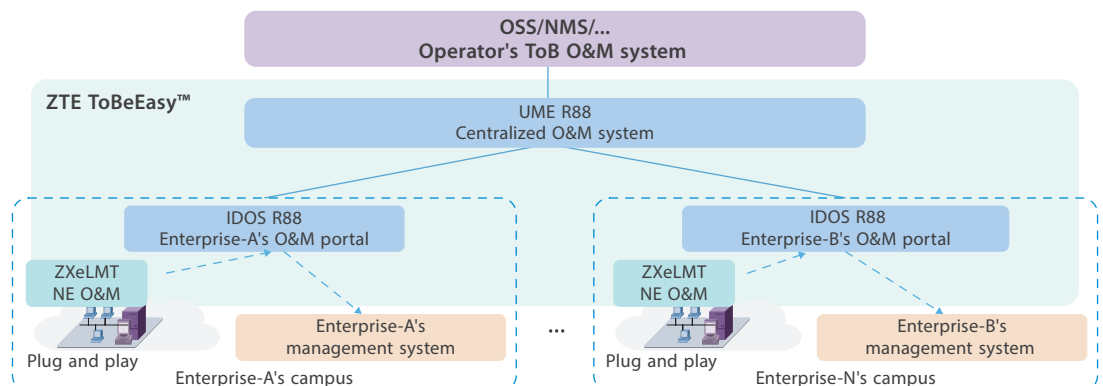
- **UME R88 centralized O&M system:** It provides end-to-end management capabilities across the RAN, core network, cloud resource, bearer network, fixed network and CPE, and truly achieves unified cloud-network management.
- **IDOS enterprise O&M portal:** It provides enhanced service O&M and enterprise-oriented connections. Taking the service perspective as the core, it analyzes the status of the network and services, monitors the service trend in real time, and ensures normal operation of service connections in the ToB campus.
- **ZXeLMT local NE O&M:** It provides professional emergency O&M from the perspective of a single NE, and has basic O&M capabilities such as on-site data configuration, signaling trace, performance monitoring and fault diagnosis.

The ToB private network O&M not only manages end-to-end network devices but also focuses on 5G-based industrial applications. ZTE's ToBeEasy simplified O&M solution designed for ToB networks has the following features:

- **Plug-and-play:** The devices are pre-assembled with one click on the production line. The whole equipment is delivered out of the factory and powered in the enterprise, and re-configured according to the on-site environment. Thus ToB products can be delivered from production to delivery without design, installation and debugging, and support plug-and-play. The auto integration center (AIC) tool is used for delivery automation, which shortens the time to service deployment to hours.
- **Remote managed services:** Remote ToB O&M systems are deployed in a centralized way by ZTE or the operator to provide remote network fault detection and handling capabilities and guarantee the network quality. This provides enterprise users with O&M services, and reduces the pressure on network maintenances. This also relieves enterprise users from O&M services and reduces their pressure on network maintenance.

- **Rapid recovery:** When network faults occur in the system, three ToB emergency operations are suggested to enterprise users: restart, switch over and re-installation, to guide the users to recover most of the network faults quickly. In addition, one-click collection of system logs can be used to backhaul the logs when the fault occurs, so that the fault can be analyzed later and the network system can be improved and optimized.
- **Terminal SLA guarantee:** By deploying the enterprise O&M portal and lightweight big data system, the network connection SLA quality of key terminals can be monitored in real time. This provides enterprise users with delay, bandwidth and other key indicators, meeting their needs for monitoring the network quality of key terminals.
- **Capability exposure:** By exposing capabilities that involve network equipment, enterprise connection service management, cloud management and industry app deployment, the solution satisfies operators and enterprises' O&M requirements for ToB connection services and private network equipment. It also supports API orchestration and small program development, helps enterprises and operators with low-code self-development, and empowers the industry.
- **Ultimate security:** Based on the professional security management capability of the communication network, combined with the requirements of relevant security standards of various industries, the solution delivers a series of capabilities such as authority management, data protection and security domain isolation. It provides operators and enterprises with a reliable, trusted and controllable service environment.

Since its ToBeEasy simplified O&M solution was proposed in September 2021, ZTE has worked with a number of operators, enterprises and enterprise integrators at home and abroad to deploy the solution in many industry fields, helping them simplify network management, save O&M costs, and accelerate industrial digital transformation. **ZTE TECHNOLOGIES**

Boosting Smart Manufacturing with 5G Industrial Internet

Wang Zheng

Director of ZTE 5G Private
Network Planning

In November 2019, the Ministry of Industry and Information Technology (MIIT) of China issued the "5G+ Industrial Internet" 512 project promotion plan to support the integrated development of 5G and industrial Internet. Over the past two years, with the joint efforts of all industry players, the "5G+ Industrial Internet" projects under construction have been extended to over 20 key industries, playing an important role in the transformation and upgrade of China's real economy.

Requirements for 5G+ Industrial Internet

At present, China has built the world's largest commercial 5G network, and the development of China's Internet and industrial Internet has entered the fast lane. For differentiated industrial scenarios, the traditional ToC-oriented public core network cannot meet their diverse requirements for 5G.

- **Deterministic network (TSN):** The traditional ToC network can only offer the best-effort service with no guarantee of latency or jitter. A TSN network can fulfil various latency and jitter requirements, and ensure the network quality of the industrial Internet. With the development and large-scale application of the TSN technology, there is an increasing demand for 5G TSN.
- **5G LAN:** In the current industrial network, the equipment is confronted with such problems as limited cable mobility, high fiber installation costs, weak Wi-Fi security, and poor mobility. In addition, only Layer-2 access is supported, and the link has poor configurability with fixed application mode. These problems restrict the scale and flexibility of the private wireless network, which has led to a high demand for 5G LANs.
- **Ultra-low latency and ultra-high reliability communication (URLLC):** Some special scenarios, such as autonomous driving, remote control, telemedicine and VR/AR, require collision-free coordination of intelligent devices, and low-latency and high-reliability wireless communication is needed to implement real-time data exchanges to greatly improve efficiency and operational security.

ZTE Industrial Internet Solution

Industries such as manufacturing, mining, power, iron and steel, metallurgy, port and transportation all have their own pain points and difficulties, which drives the development of customized ToB core networks. In 2022, ZTE has begun to deeply integrate 5G into core services of the industry.

For intelligent manufacturing, ZTE's private network solution provides an ultra-reliable and ultra-low latency deterministic network, which combines URLLC with TSN to ensure the highly reliable operations of various equipment. At the same time, the URLLC technology and TSN deterministic network are used to ensure the real-time transmission of data in the network.

For the mining industry, ZTE's private network solution provides a 4G/5G integrated network where the 4G and 5G networks are inter-connected and operate independently from each other. The network supports data and voice connectivity between the surface and underground, and can interconnect with the third-party voice dispatching system.

For the power industry, ZTE's private network solution enables differentiated networks to meet service requirements of different scenarios. For the DTU differential protection scenario, the TSN service is provided to ensure the real-time arrival of periodic inspection packets. For the electric power detection scenario, the multicast communication service is provided to save the uplink bandwidth. For the field scenario, the 5G LAN service is provided to save the optical cable installation costs.

For other industrial scenarios, ZTE also provides different private network solutions targeting their pain points and difficulties.

ZTE Private Network O&M

To meet the network maintenance requirements of industrial customers, ZTE has launched a variety of powerful O&M tools.

For the industrial Internet, the users are more concerned about the running status and running indexes of the terminals. To meet the requirements of these customers, ZTE has launched the enterprise O&M portal iDOS system to interconnect with the enterprise's own system. It can display the key quality indexes (KQIs) as well as the KPIs for the network, so that the users can truly understand the running status of their own equipment and networks and realize self-O&M and self-management.

ZTE's Practices in 5G Industrial Internet

ZTE is actively working with leading enterprises to deploy industrial Internet powered by 5G along with other advanced technologies.

In Nanjing, ZTE's Binjiang Factory uses 5G to manufacture 5G, and connects workshop production equipment to the industrial Internet platform through 5G networks. In the production scheduling phase, end-to-end visualization, low latency, and intelligence are enabled. In the warehousing & distribution phase, processes from the storage of raw materials to the delivery of finished products become intelligent. Production workshops achieve automatic production status perception, automatic collection of production data, and real-time analysis of product data.

Since the signing of a strategic cooperation agreement in 2019, ZTE and Sany Heavy Industry have been exploring the application of 5G technologies in Sany's industrial parks in Beijing and Changsha by building 5G networks and conducting 5G service demonstrations. They have deployed or will deploy applications such as 5G AR, 5G real-time industrial control, 5G cloud AGV, 5G remote control and unmanned driving, 5G high-precision positioning and unattended security in the 5G park, speeding up the development of a model for industrial 5G.

In Zhejiang, ZTE and China Telecom Zhejiang Branch assisted SUPCON in commissioning China's first 5G SA site, and successfully put "5G slicing + edge computing + intelligent manufacturing" into trial commercial use, helping the enterprise build a new 5G smart factory. The innovative "5G slicing + edge computing + intelligent manufacturing" solution guarantees video streams with slicing, reduces the latency, jitter and packet loss rate of video transmission, and improves the accuracy and real-time performance of video analysis.

In 2021, the MIIT unveiled the industrial Internet innovation and development action plan (2021-2023). According to the plan, 30 5G fully-connected factories will be built in 10 key industries by 2023, and ZTE has made a good start with its practices. We believe that with the joint efforts of the entire industry chain, 5G fully-connected factories will be widely constructed across the country in the next three years to fast-track industrial Internet development. **ZTE TECHNOLOGIES**

Intelligent Transportation Private Network Built on NPN-Based Private/Public Network Interworking

Ye Jianyang

Chief Engineer of ZTE Private Network Product Planning

By the end of 2020, the length of China's railways in service had reached 146,300 km, of which the length of high-speed railways had reached 38,000 km. High-speed rails have become a "new business card" of China. Due to high-speed movement as well as signal shielding, loss and frequency shift by metal vehicles, 5G network coverage is facing great challenges in the transportation represented by high-speed rails, subways, and airplanes. If a 5G network is directly deployed inside the transportation vehicle and moves with it, there will be no penetration loss, Doppler shift or frequent handover. This can address 5G connection needs of a large number of sensors and cameras in transportation vehicles such as high-speed rails and airplanes, and meet the needs of wiring and maintenance as well.

However, for public users, both network registration and control are implemented in the ground 5G public network. If the private network inside the transportation vehicle is used to access the 5G network, it is necessary to solve the problem of interworking between the private network on the high-speed mobile vehicle and the static ground network.

In the 5G protocols defined by 3GPP, the concept of non-public network (NPN) is put forward, and the interworking solution between stand-alone NPN (SNPN) and public land mobile network (PLMN) is described accordingly. As shown in Fig. 1, SNPN is regarded as a non-3GPP access point of PLMN, and an encrypted tunnel is established between the data network (DN) and the non-3GPP interworking function (N3IWF) in the public network, thus realizing the interworking between NPN (private network) and PLMN (public network) while maintaining their relative independence.

◀ *Fig. 1. Intelligent transportation private network bulit on NPN-based private/public network interworking.*
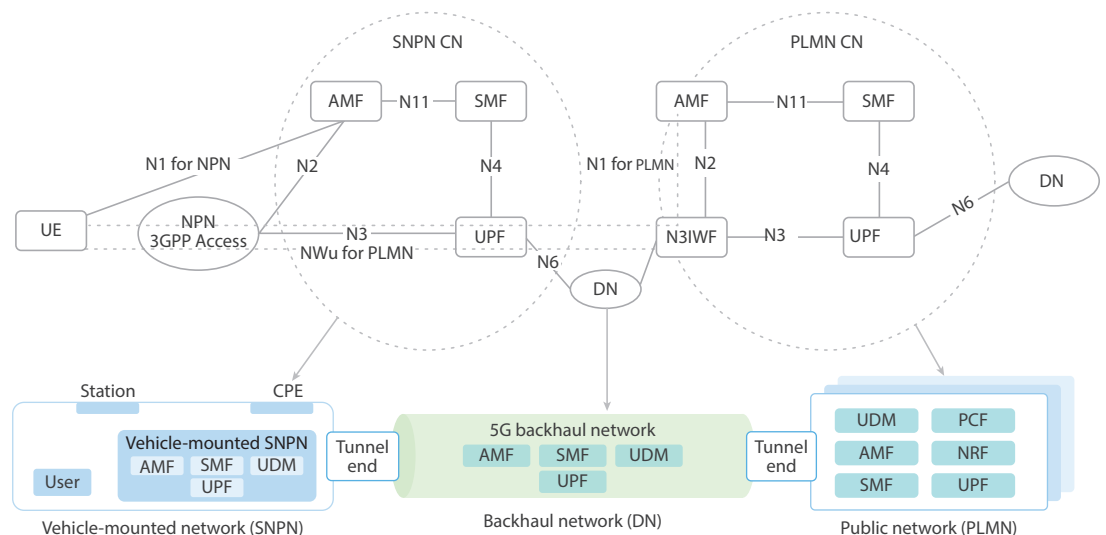
In this architecture, SNPN, PLMN and DN are all relatively independent, which is of great reference significance to the construction of a high-speed mobile transportation network. If the transportation network is divided into three parts, the network inside the carriage can be regarded as a SNPN, and the ground network as a PLMN. The backhaul channel between the carriage network and the ground network can be built through the DN along the track.

In the carriage network part, lightweight i5GC products can be used to deploy SNPN, and high-performance CPEs can be used at the tunnel end, with CPE antenna extending to the outside of the carriage. This eliminates signal attenuation caused by the penetration loss in the carriage.

The backhaul network can be covered by the existing 5G network along the track or built with large bandwidth (millimeter wave). Based on the backhaul network (DN), an IPSec tunnel is established between the UPF of vehicle-mounted SNPN and the N3IWF of PLMN to connect the moving carriage with the static ground.

Assuming that the user is anchored on PLMN (the same as the one anchored on SNPN), it can be understood as a handover. The movement of public users, such as passengers getting on/off the train, can be regarded as a network handover, that is, getting on the train means a handover from PLMN to SNPN, while getting off the train means a handover from SNPN to PLMN.

In the high-speed rail scenario, compared with the standard NPN solution, SNPN can be evolved into a private high-speed rail network solution, and the control plane of SNPN can be moved to the ground. In this way, the interworking between SNPN and PLMN is relatively static, and the route interworking solution can be directly adopted. The small carriage station used as the SNPN base station connects the carriage UPF to unload the video content of the same quality. The backhaul channel between the carriage (SNPN-UPF) and the private high-speed rail

network (SNPN-control plane) uses 5G coverage along the way. The SNPN control plane on the ground serves as a convergence point to connect a large number of trains while interworking with PLMN, thus avoiding direct multipoint-to-multipoint tunnel connection between trains and PLMN. This simplifies network topology, reduces the complexity of interconnection, and improves network security and reliability.

Similarly, in the subway scenario, the small carriage station serves as the PLMN base station, and SNPN uses millimeter-wave antennas to build a super-large bandwidth backhaul network. This is used for rental by PLMN operators and facilitates existing operators to extend their network services to subway carriage.

In the aviation scenario, since PLMN cannot cover the flight altitude, the air-to-ground (ATG) network based on SNPN can be specially built as the backhaul network. As a backhaul network user, CPE in the aircraft cabin can offer Wi-Fi service directly to the Wi-Fi users in the cabin, and can provide VoWi-Fi service for the mobile phone with the support of the ground network. Moreover, the CPE can build a backhaul tunnel with the ground network through the backhaul network. In this way, the connection between PLMN and the airborne SNPN is established, which makes it possible to deliver 5G services directly to the users in the aircraft cabin.

With the further deployment of 5G networks, enjoying convenient 5G services in high-speed vehicles will become a necessity for people. The intelligent transportation private network built on the NPN-based private/public interworking mechanism provides a good solution to signal loss caused by vehicles, handover and frequency shift caused by high-speed movement, user roaming, and handover management mechanism. Building a unified intelligent transportation private network that supports aviation, high-speed rail, and subway will soon make it possible for users to enjoy convenient 5G services in high-speed trains, subways and airplanes. **ZTE TECHNOLOGIES**

5G Indoor Integrated Positioning Solution Helps Digital Transformation of Vertical Industries

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Director of ZTE RAN
Power Solution

5G has the characteristics of high bandwidth, low latency and massive connections, which help to completely change the information infrastructure and bring the whole society into the era of intelligent Internet of things. In addition to information service, location service is also an important basic service need in the information society. With the booming growth of global 5G deployment and vertical applications, the industry urgently needs high-precision 5G positioning and 5G integrated out-of-band positioning technologies.

With full indoor and outdoor coverage, a variety of terminals, and strong application capabilities, mobile network is an ideal carrier of the basic positioning platform. In the 3G and 4G era, mobile positioning technologies emerged such as cell-assisted positioning and observed time difference of arrival (OTDOA), and out-of-band integrated positioning technologies such as GPS/AGPS appeared at the terminal and application side, which could better meet the needs of consumers' conventional positioning applications. However, there are still many problems in positioning accuracy, speed, and single-user location based services (LBS) integration, and there is also a big gap in meeting the diverse needs of vertical industries. Now, in order to solve these problems, 5G integrated positioning solution has been developed.

Pressing Needs

Positioning service scenarios are divided into two types: outdoor positioning and indoor positioning. Thanks to the development of satellite positioning, cellular-assisted positioning, digital map technology, and upper-layer applications over the years, the outdoor location service architecture equipped with satellite positioning and telecom network assisted positioning has matured. 5G outdoor positioning focuses on improving the positioning accuracy of outdoor base stations. Now many technologies such as UTDOA/RTT have been put into commercial use to improve positioning accuracy and system capacity.

However, due to the limited GPS satellite coverage and complicated indoor scenarios, there has been a

lack of a dominant indoor positioning platform. Some local indoor positioning technologies, such as Wi-Fi, Bluetooth, UWB, laser infrared and visual positioning, are limited to local scenarios. A ubiquitous, instant, universal and high-accuracy indoor positioning service platform is urgently needed in the industry, and various existing out-of-band positioning networks can be integrated and managed.
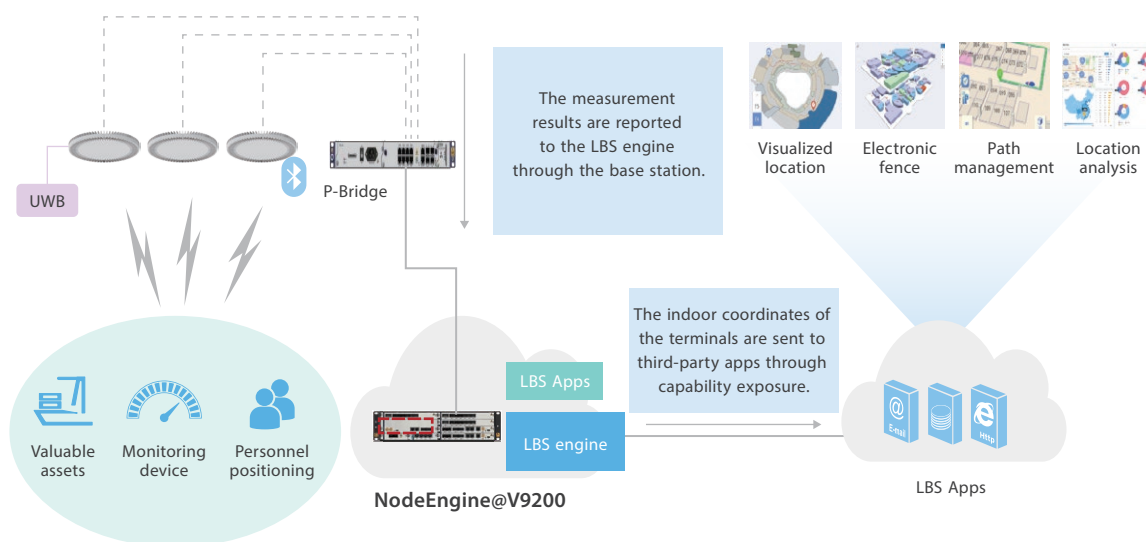
Solution

In response to the need for unified positioning in indoor scenarios, ZTE has launched an innovative 5G indoor integrated positioning solution, with the overall framework shown in Fig. 1.

ZTE's 5G indoor integrated positioning solution uses its latest indoor 5G NR and can provide basic 5G high-precision indoor positioning services in all scenarios. Leveraging 5G large bandwidth and multi-beam feature, 5G NR can support multiple positioning technologies such as ECID and UTDOA. The ECID positioning algorithm can achieve an accuracy of about one fourth to one third of inter-site distance, with the highest positioning accuracy of up to one meter in an ideal state of UTDOA.

ZTE 5G NR also provides cascading interfaces that can be rapidly cascaded to out-of-band Bluetooth/UWB positioning systems to implement 5G+UWB or Bluetooth AOA integrated positioning. The out-of-band positioning base station and the 5G intelligent indoor DAS equipment are integrated and co-located to fully reuse 5G NR power supply and transmission resources. They support plug-and-play, share the future maintenance resources, and provide the positioning of sub-meter level. Bluetooth AOA can reach a positioning accuracy of 30–50 cm, and UWB 20–30 cm.

Based on ZTE's innovative site-level computing power engine NodeEngine, BBU in the existing network can function as an intelligent edge base station only by inserting a computing power board into the BBU, so that a variety of value-added

◀ *Fig. 1. ZTE's 5G indoor integrated positioning solution.*

services can be easily deployed, including local LBS at the RAN side, 5G positioning engine, UWB/Bluetooth positioning engine and LBS services. And meanwhile, both 5G positioning engine and UWB/Bluetooth positioning engine can provide a unified open location interface to interconnect with third-party applications, thus meeting the LBS needs of the industry in a more flexible manner.

Commercialization

ZTE has partnered with operators and LBS industry players to actively promote the commercial use of 5G indoor integrated positioning solution and run commercial trials in shopping malls, transportation hubs, and intelligent manufacturing scenarios.

The Canton Tower Station Project (China Guangzhou Metro) uses the 5G Qcell high-precision indoor integrated positioning system to provide users with location applications. An administrator can use the terminal to open the map to view the locations of 5G terminals in real time, and view the traffic heat map and traffic distribution through the big data platform. In addition, the system provides an open API interface to interconnect with third-party applications, providing customers with location services such as accurate indoor navigation and discount pushes.

At the Grandview Mall in Guangzhou, a typical big shopping mall in China, the operator has rapidly deployed the 5G positioning service simply by upgrading the RAN system. The solution supports the latest Release 16 positioning techniques with the positioning accuracy reaching 2 meters in line-of-sight (LOS) conditions. Moreover, this project enables perfect interconnection between the local LBS server and the operator's mobile big data platform, so that the 5G local positioning service can be delivered quickly without any change to the core network.

China's Yunnan Shenhuo project adopts the applications of 5G, MEC, positioning and digital twin. 5G and MEC provide cloud-network service for the campus, while Bluetooth offers location-based service. This helps to create a model for the application of 5G+ industrial Internet in the field of non-ferrous metal processing. The solution combines advanced 5G, indoor positioning and visualization technologies with modern management to fully experience the personnel, equipment and environment in the factory, and establish an efficient connection to the huge environment of the factory area. The digital twin technology is used to complete 3D modeling of aluminum ingot yard, air compressor, laboratory, maintenance workshop, and alumina storage and transportation in the campus. According to the location information of people and things in the campus, the solution combines the operation of the production system in the factory area with enterprise management to realize optimal operation, control, and management of the enterprise, and provide services for the management of personnel, equipment and materials in the campus.

ZTE will continue to innovate in the solutions with its positioning industry partners, and deepen the integration of 5G positioning and the conventional LBS technologies such as satellite and Bluetooth/UWB. It will also verify a variety of 5G positioning technologies in multiple scenarios, create multi-scenario integrated positioning capabilities, and provide end-to-end LBS solutions to enable the digital transformation of vertical industries. **ZTE TECHNOLOGIES**

Port 5G Private Network Design Solution

P ort is an important hub of global shipping, and the efficiency of port operation is closely related to its automation and intelligence. Since China's 5G license was officially issued in 2019, the application of 5G in port container terminals has been gradually carried out. The port has high requirements for safe production, complex physical environment and diverse service requirements. The 5G public network solution cannot meet multi-scenario service needs of the port in terms of capacity, coverage, latency and reliability. In this context, ZTE has proposed an effective design solution for port 5G private network, which has been verified in a number of port projects and can be replicated on a large scale.

5G Network Needed for Smart Port

The port operation process is divided into two categories: vertical transport system and horizontal transport system, and involves vertical transport by quayside container crane, container tally, horizontal transport inside the container yards, and vertical transport by gantry container crane. Security and efficiency are basic requirements of port operators. Smart ports include the following scenarios:

- **Communication with offshore anchorage:** The offshore anchorage is generally more than 20 km away from the shore. Before entering the port, the cargo ship is anchored at the anchorage to handle a series of work, such as declaration, joint inspection, navigation and berthing, which requires phone calls and data backhaul.

- **Remote control of quayside container crane and intelligent tally:** After the container ship is berthed, several quayside container cranes lift containers from the ship to the container truck. More than 20 cameras and programmable logic controllers (PLC) are installed on one quayside container crane. The driver in the office can remotely control the crane through the multi-angle video and console. When transporting containers, the intelligent tally system automatically identifies the container number, damage and other information, and the tallyman can complete the tally work remotely. The quayside container crane is 50 meters high and has high uplink video traffic. PLC requires low latency and high reliability.

- **Remote control of unmanned container trucks and gantry crane:** Unmanned container trucks transport containers between docks and container yards, and send back vehicle status and video data in real time. In special cases, the remote driver takes over the driving and removes obstacles. The containers stacked in the yard seriously block and reflect wireless signals. Logistics turnover causes the stacking height of the container to change from 0 to 20 meters. When the height is low, the inter-cell interference of wireless signals is serious. The remote operation

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principle of gantry cranes is similar to that of quayside container cranes, but its network requirement is lower than that of quayside container cranes.

● **Drone preventive maintenance:** The port attaches great importance to safety production and carries out preventive maintenance regularly. Because the port covers a large area and the height of the ship can reach 100 meters, manual preventive maintenance is difficult and inefficient. At 120 meters in the air, the drone can complete a large-scale preventive maintenance rapidly, and discover security risks in time through the received HD video and image recognition.

Building Independent 5G Private Network for Hierarchical Wireless Coverage

There are many kinds of port services, which have high requirements for network capacity, delay, security and reliability. Generally, an independent 5G private network architecture is built, with dedicated 5G base stations, dedicated user plane function (UPF) or miniaturized 5GC moved down to the port campus. This solution ensures that user data is not sent out of the port, realizes accurate wireless network planning, and guarantees service experience.

The port features diverse wireless coverage scenarios, so it is necessary to design network coverage layer by layer (Fig. 1).

● Covering the ground roads and yards with heights from 0 to 20 meters can meet the service requirements of unmanned container trucks and gantry cranes. The external narrow beam antennas of RRU are used to cover the road to reduce the downlink interference to the adjacent roads. The interference cancellation technology is also used to suppress the uplink interference from adjacent road terminals to the local road. When multiple RRUs on a single road are combined by one SuperCell, there is no need for cell handover when the truck goes through, which improves service experience.

● Covering the berth with a height of about 50 meters can meet the service requirements of quayside container cranes and intelligent tally. 64TR AAU is installed on a lamp pole more than 20 meters high to cover the quayside container crane. By configuring vertical beams, the quayside container crane with a height of 50 meters can be accurately covered to reduce the interference of horizontal beams to neighbor cells.

● Covering the low altitude of about 120 meters can meet the service requirements of drone preventive

Fig. 1. Typical port 5G networking solution. ▶
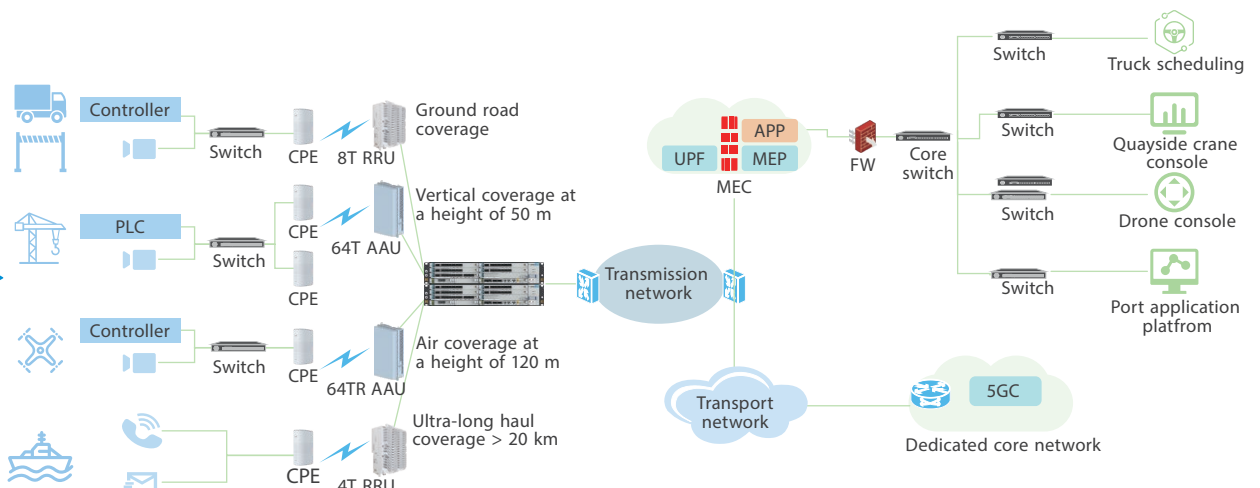
maintenance. AAU is used for air coverage. According to the link budget and simulation, the site is accurately planned to achieve seamless airspace coverage, suppress interference from adjacent cells and ensure a safe flight of the drone in a wide range.

- Covering the ultra-long haul above the sea surface 20 km can meet the communication needs of anchorage ships. According to the theoretical calculation, a base station site needs to be built at an altitude of 80 to 100 meters to cover the offshore anchorage. A low frequency band is selected, and the transmission loss will be low. The PRACH coverage enhancement can be provided to meet the communication needs of the sea surface above 20 km.

High Availability and Differentiated Scheduling Policies to Guarantee Multi-service Experience

The port operates all day, and any transport shutdown caused by failure will bring great losses, so the design of port 5G private network must consider the high availability scheme. As end-to-end network availability equals to the multiplication of the availability of each node in the network, it is necessary to increase the availability of each node. At the network access side, two CPEs are deployed to establish dual links that support active/standby mode and load sharing mode, so that the availability of terminal equipment can be enhanced. At the same time, 5G and the original optical network of the port form wireless and wired backup links, which increases availability while protecting the existing investment in network construction. At the network system side, single-board and network-level backup solutions can be deployed. It is necessary to provide the backup of power boards, baseband boards,

and the main control board, and BBUs and RRUs also need to be backed up to build a dual-band dual-layer wireless network. When the active device fails, the network can be restored quickly through active/standby switching.

There are many kinds of services at the port, and their requirements for the network vary greatly. Under the default network configuration, there will be competition for network resources among services, resulting in network congestion and a decline in service experience. Different services can be isolated through network slicing, and different radio algorithm parameters can be configured in the slices to implement differential guarantee of the services.

For the control service of remote quayside container crane, physical resource blocks (PRB) can be reserved to provide resource guarantee, user-level pre-scheduling can be configured to reduce latency, and conservative scheduling can be configured to improve transmission reliability. For the video backhaul service, high-target block error rate (BLER) can be configured to increase the weight of QoS scheduling. For the data backhaul service with low real-time requirements, low-priority QoS can be configured, and the resource can be preempted by other high-priority services.

ZTE's port 5G private network design solution has been deployed and verified in many ports. A range of port services such as remote control of quayside container crane, intelligent tally, unmanned container trucks, drone preventive maintenance, and ultra-long-haul coverage of offshore anchorage have passed the trial verification and pressure tests, and have gradually expanded their application scale. A 5G private network customized for the port will enhance the intelligence of the port and help it operate efficiently. **ZTE TECHNOLOGIES**

5G Empowers Caojiatan Smart Coal Mine

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Chief Engineer of ZTE CCN Product Planning

He Guangming

Supervisor of the Energy Market of ZTE Industry Digitalization Solution Department

In terms of intelligent mining, Caojiatan Coal Mine in China's Shaanxi Province has always been at the forefront of the industry. As a large-scale coal mine demonstration base developed in accordance with China's 12th Five-Year Plan, it has been rated as an excellent industrialization-informatization integration project by the China National Coal Association and a high-quality engineering project by Shaanxi Coal Industry's Construction Project Quality Supervision Center. In a response to the call for intelligent construction of coal mines, Caojiatan Coal Mine cooperates with China Unicom Shaanxi Branch, Shaanxi ZHIN Technology and ZTE, and adopts ZTE's 5G iCube cloud-network integration solution to construct the 5G communication system for intelligent mining.

The New Massive Data Challenge

Traditional mines mainly use 4G cellular network, Wi-Fi and other wireless communication technologies. Due to complex working environment, including restricted underground space, high levels of dust, and frequent movements of large equipment, high data transmission latency and damage to optical cables often occur during mining operations, seriously threatening safe production. With the development of intelligent mining, a large number of existing and new cameras, sensors, and controllers need to be connected to the network. This requires wide coverage and large bandwidth to support massive device connectivity and HD video backhaul, and also low latency to enable production control with the underground equipment. Therefore, the mining industrial network is facing severe challenges. Traditional wireless communication technologies cannot meet the evolution requirements of intelligent mining and need to be replaced by a new generation of wireless technologies such as 5G.

## Build Digital Foundation with 5G iCube

Taking actual problems as the starting point, Caojiatan Coal Mine uses ZTE's 5G iCube cloud-network solution, and works together with ZTE to build a digital foundation for intelligent mining. The key highlight of this solution lies in the integration of 5G's high-bandwidth and low-latency communication capabilities with the powerful computing capabilities of private cloud servers, connecting the communication links from the underground, cloud, and surface, and integrating all the underground mining services into a unified framework of communication, computing, and management and control.

In the underground, a large number of 5G communication modules are deployed to provide functional modules such as data access, voice, HD video, unified dispatching and personnel positioning for all the systems in the mining area. In the cloud, the iCube cloud network cabinet is deployed in the central equipment room, building the unified cloud foundation, and the dedicated

4G/5G integrated core network, dedicated VoNR/VoLTE IMS core network, 3-in-1 integrated NM system (UME R88) and other basic services are deployed. Above the ground, through the management & control center, data system, and application center, data can be managed visually. The architecture of the 5G iCube cloud-network solution is shown in Fig. 1.

Moreover, the 5G iCube cloud-network solution used by Caojiatan Coal Mine has been upgraded from the following five dimensions:

- **Integrated digital foundation to realize one-network management and control:** By interconnecting with the existing 4G base stations, the system completes integration of the 4G and 5G networks in the mining area, realizing the same card and number for the 4G/5G terminals, seamless coverage and lossless handovers. VoLTE/VoNR voice capability is integrated to provide real-time voice and HD video functions for terminals such as 4G/5G mobile phones, personal equipment and fixed telephones. The system also supports supplementary and value-added services such as CTX groups, call forwarding and call transfer, and voice
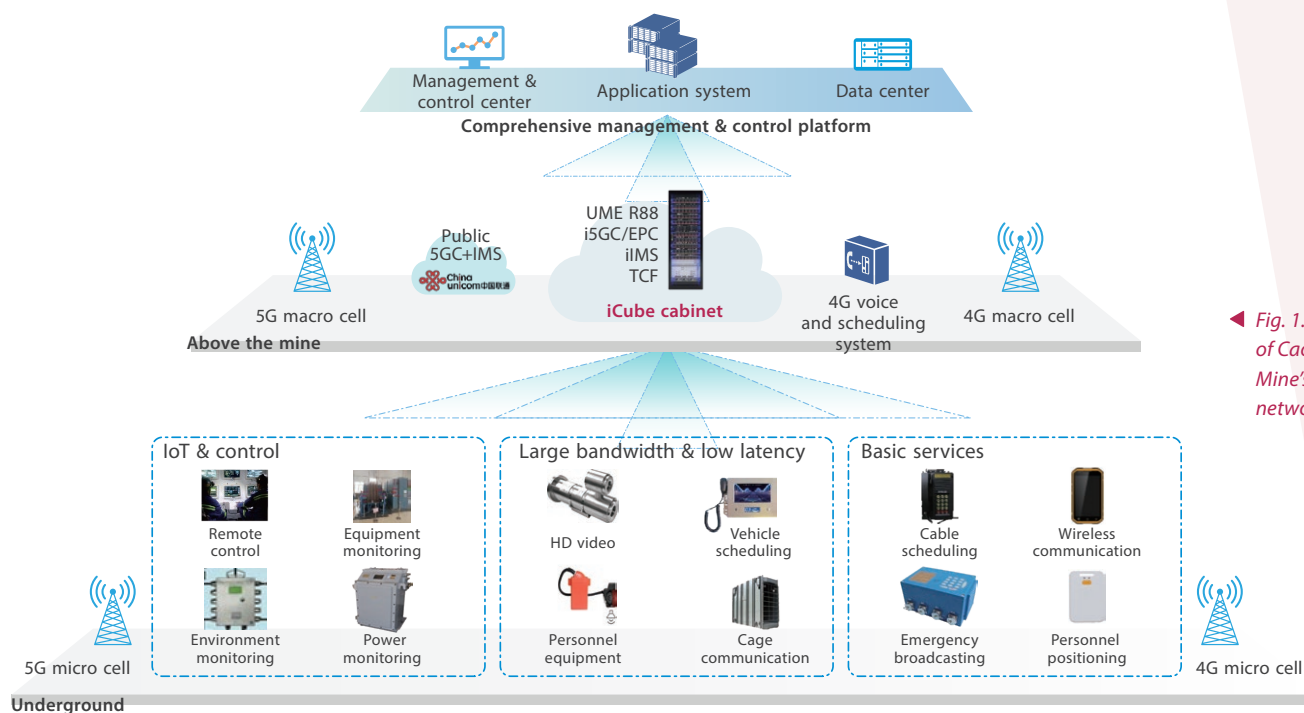
◀ *Fig. 1. Architecture of Caojiatan Coal Mine's 5G private network.*

interworking between private and public networks.

- **Implementing MOCN network sharing solution to achieve seamless connection between the public and private networks:** When users on the public 5G network access the 5G base station, they access the public 5GC of China Unicom based on the PLMN ID1, and normally use the public network's data, voice and SMS services. Users on the 5G private network or 4G & 5G integrated network access the i5GC of the mine based on the PLMN ID2, which allows local traffic offloading, and they use the voice and data services of the mining intranet and interconnect with the mining application server.

- **End-to-end mechanism to guarantee the service security and reliability:** Based on the resources reserved for wireless PRB and dynamic resource sharing, the system provides the security guarantee for high-priority services of the mining area. With the deployment of a completely independent 5G private network, the services of the mining area will not be affected even if the network between the mining area and the public network breaks down. The independent 100G bearer ring network is physically isolated from public network, and the optical cable failures outside the mining area will not affect the private network.

- **Interconnection with the third-party dispatching system to enrich the mine service ecosystem:** The iCube can successfully interwork with the third-party dispatching system to verify the services such as basic audio/video call, holding, pick-up, forced insertion and forced release. This effectively integrates the communication resources, achieves coordinated control and accurate dispatching, and improves work efficiency.

- **3-in-1 management improving the private network's O&M efficiency:** The

UME R88 integrated equipment enables the unified management of core network, wireless network and bearer network, reducing the O&M complexity, while being interconnected with the unified management and control platform of the mining area. According to statistical data, it can save the human cost of maintaining communication equipment by more than 20% annually.

Relying on the 5G digital communication foundation, Caojiatan Coal Mine has successfully established innovative intelligent systems covering smart grid maintenance, smart belt detection, automatic drainage control, smart frequency conversion ventilation, and smart auxiliary transportation. All systems operate in good conditions.

Conclusion

The successful implementation of the "5G iCube cloud-network solution" in Caojiatan Coal Mine marks the first integrated deployment of cloud, network, application and maintenance in the industry, which lays the foundation for the continuous intelligent upgrade and reconstruction of the mine and sets an example for the intelligent construction of other mines in China.

Looking to the future, Caojiatan Coal Mine will continue its commitment to innovation, promote the "intelligent, real-time, less-manned, and unmanned" transformation of production mode, and provide core technical support for intelligent coal mining, intelligent transportation, safety and independence guarantees, and intelligent operation management. Embracing intelligent manufacturing, ZTE will work with multiple parties to promote the implementation of "5G iCube cloud-network integration solution", driving the intelligent development of coal mines in China. **ZTE TECHNOLOGIES**

Building a 5G Smart Steel Plant to Lead Digital Transformation in Steel Industry

Baosteel Group Company Limited and Wuhan Iron and Steel (Group) Company Limited (WISCO) were jointly reorganized in September 2016. The merged China Baowu Steel Group Corporation (hereinafter referred to as "China Baowu") is the most modern and competitive iron and steel joint enterprise in China, and also a super-large modern iron and steel joint enterprise in the world. China Baowu continues to promote intelligent manufacturing and digital transformation, and proposes four evaluation criteria for intelligent manufacturing process of iron and steel: centralized on-site operation rooms, robot operation posts, remote O&M monitoring, and online service procedures. Under a unified industrial Internet architecture, China Baowu is committed to promoting the three-cross integration, that is cross-industry, cross-space, and cross-man-machine interfaces.

WISCO encountered some challenges in promoting digital transformation. Its existing siloed information system made it difficult to exchange information between systems, and its communication networks could not have sufficient coverage and were not scalable enough to meet the requirements of smart manufacturing. To meet the requirements of four evaluation criteria and three-cross integration, WISCO introduced the 5G private network technology to leverage 5G advantages such as low latency, large bandwidth, and wide connections to achieve digital transformation. In the first half of
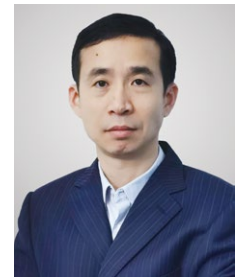
Jing Sheng

Marketing Director of ZTE CCN Products

2021, Hubei Unicom joined hands with ZTE and CISDI to build the 5G private network project of WISCO. According to the requirements of intelligent manufacturing business and the characteristics of the iron and steel industry, Hubei Unicom chose independent private network mode to build the largest 5G private network in China for WISCO (Fig. 1).

WISCO's 5G private network is exclusively provided by ZTE. The whole core network is offloaded and the complete set of 5GC NEs are deployed in the communication equipment room of the factory, which provide 5G data services for private users (using private network cards) and support

value-added services such as private network voice/SMS as needed. Based on the network function virtualization (NFV) architecture, the 5G private network adopts the general X86 server and networking mode in accordance with the CT resource pool standard, and provides separation of control, computing and storage, so as to meet the needs of service growth through hardware expansion and software upgrade. It also adopts mature 3GPP R15 specifications of the industry, provides good terminal and network compatibility, and supports the continuous evolution to the latest R16/R17 version.
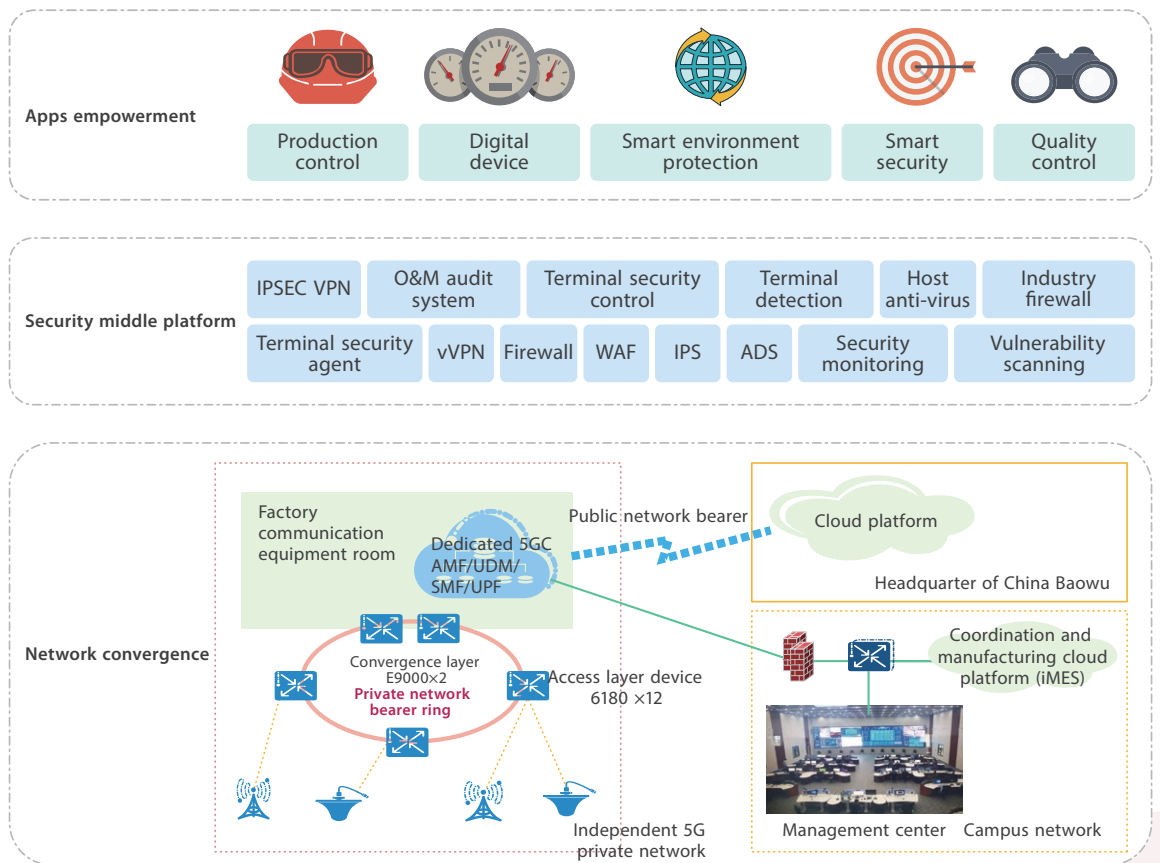
Fig. 1. 5G private network architecture for WISCO. ▶

Fig. 2. The project of "Baosteel 5G+ full-connection factory's innovative application and practice" won the first prize in the fourth "Bloom Cup" 5G Application Contest in China.

Through software upgrade, it supports innovative features such as 5G LAN, QoS monitoring, and TSN, and continuously empowers smart manufacturing.

A total of 51 5G macro sites have been set up and commissioned in WISCO's 5G private network. Its outdoor coverage tested reaches 99.02%, with an average downlink throughput of 800.59 Mbps and an average uplink throughput of 150.78 Mbps.

The entire 5G network is independently operated by WISCO, and all security policy rights are fully controlled, achieving the highest level of security, control and management. The 5G private network is highly independent from the public network on the physical transmission layer. There is no need to backhaul data and signaling flows in the campus to the public network. The campus network is totally isolated from the public network, guaranteeing data security in the campus. WISCO is the first to implement the concept of "ALL IN ONE" smart manufacturing. It has built the management and control center and four major operation centers for iron making, steel making, CSP and hot rolling. Its operation rooms are centralized and far away from the site, making the functions such as data integration, real-time collection, one-click steel making and smart transportation a reality. With the gradual maturity of terminal products of the R16 standard and the rapid development of various innovative technologies such as 5G LAN, TSN, digital twin and XR, various applications will also be put into use on a large scale.

The project of "Baosteel 5G+ full-connection factory's innovative application and practice" jointly built by Hubei Unicom, WISCO, ZTE and CISDI won the first prize in the fourth "Bloom Cup" 5G Application Contest in China (Fig. 2). Together with WISCO and Hubei Unicom, ZTE will continue to explore 5G+ industrial Internet, practice 5G+ innovative applications, and comprehensively assist the digital and intelligent transformation of the iron and steel industry. ZTE TECHNOLOGIES

To enable connectivity and trust everywhere