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ZTE TECHNOLOGIES

VIP Voice

EMR: To Be a Source of Pride for Indonesia

Expert View

5G+ Industrial Internet: Creating a New Era of Fully-Connected Factories

Special Topic

5G Fully-Connected Factory

Cover Figure | *Hendra Gunawan, CTO of EMR*

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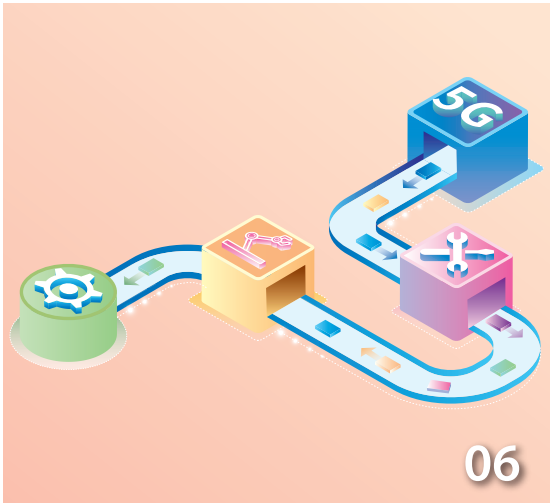


Success Story

EMR: To Be a Source of Pride for Indonesia

Reporter: Faris Wen

Hendra Gunawan, CTO of EMR

PT. Eka Mas Republik (EMR) is a fiber optic-based internet service provider that provides internet and pay-TV services for families and businesses in Indonesia. The company is growing rapidly with the aim of becoming a source of pride for Indonesia. "EMR has set a goal of expanding to up to 50 cities in Indonesia by the end of the year," said Hendra Gunawan, CTO of EMR, in a recent interview where he discussed the secrets behind the company's rapid growth, the challenges and opportunities it must address, and its infrastructure expansion efforts.

What's the state of play in the fixed broadband market in Indonesia?

The fixed broadband market in Indonesia is fiercely competitive, yet it remains healthy. With numerous established players in the industry, consumers in Indonesia have a wide range of fixed broadband internet options to choose from. The market is experiencing high demand due to the growing prevalence of online activities such as virtual meetings, gaming, small and medium-sized enterprises, and live shopping. Furthermore, Indonesia's high level of digitalization is contributing to the growth of the fixed broadband market. EMR notes that the Indonesian people are eager to try out new internet providers, making the market even more appealing to potential players. Despite the competition, there is still ample room for growth in the industry, thanks to the high demand for digital services and the Indonesian people's enthusiasm for them.

EMR has become one of the fastest growing internet service providers in the country. What sets it apart from other players on the market? Especially, what strategies are you adopting to provide fast services at affordable prices?

EMR's unwavering dedication to providing top-quality internet and exceptional after-sales service has earned it the reputation of being one of the country's fastest-growing internet service providers. What sets EMR apart from its competitors is its emphasis on product excellence, which includes symmetrical upload and download speeds at a 1:1 ratio, unlimited data usage, and 100% fiber-optic connectivity. EMR has also established a streamlined communication system for all its customers. By digitalizing processes, such as auto-ticketing and interactive chatbots, EMR has created a more efficient customer service experience. In addition to offering outstanding products and customer service, EMR adapts to market trends and needs and provides tailor-made solutions to meet them. This approach enables EMR to deliver high-speed internet services at affordable prices without compromising on quality. By prioritizing internet quality and after-sales service, EMR has become the preferred choice for those seeking fast and dependable internet services.

In the fast evolving digital age, what are the challenges and opportunities you must address to remain successful?

To stay successful in the fast-evolving digital age, EMR must navigate both challenges and opportunities. One of the

primary challenges is infrastructure, as EMR must continue to expand its infrastructure to provide the best possible internet service to its customers. Nonetheless, EMR perceives this as an opportunity and has set a goal of expanding to up to 50 cities in Indonesia by the end of the year by constructing additional infrastructure.

Keeping up with the ever-changing technology landscape is another challenge, but EMR remains current by adapting to the latest market trends and needs. One of the opportunities that EMR identifies is that Indonesia is a rapidly developing country with an increasingly digitally literate population. In particular, after the pandemic, more people rely on the Internet for their daily activities, making it an essential need for everyone. EMR strives to be the solution of choice that people turn to for assistance with their daily activities.

EMR also acknowledges that infrastructure is a significant challenge, but it has implemented initiatives in its business processes that have earned recognition from the Asian Telecom Awards 2023 as the Infrastructure Initiatives of the Year (Indonesia). By continuously enhancing its processes and infrastructure, EMR can overcome challenges and capitalize on opportunities to remain successful in the ever-evolving digital age.

How are you expanding the infrastructure and services for your customers?

EMR is expanding its infrastructure and services to provide the best internet services to its customers. Firstly, EMR has made many breakthroughs and innovations in its infrastructure projects throughout 2022. These breakthroughs include business process automation, end-to-end integrated data management, funnel and market analysis for expansion, and improved welfare for project teams. These initiatives are part of EMR's way of expanding its infrastructure.

EMR is also focusing on providing coverage to residential areas and small-medium enterprises. In addition to building infrastructure, EMR is building strategic partnerships and collaborating with trusted partners to expand its services even further. EMR believes that good infrastructure delivers good internet services, which will maintain customers better. Therefore, it is committed to continually improving its infrastructure and services.

On the core network side, EMR has upgraded its infrastructure to handle the anticipated 1 Million subscribers without congestion. EMR has moved from 10G and 40G to 100G interfaces as well as transformed intercity backhaul from using Metro Ethernet to DWDM.

By investing in infrastructure, developing initiatives, and building strategic partnerships, EMR can provide the best internet services to its customers and continue to expand its reach in Indonesia.

What new technologies are you looking to leverage in order to deliver the best user experience?

EMR is always looking for new technologies to enhance its customers' experience. One such technology is auto-detection, which enables EMR to detect problems before they become significant issues. With this technology, EMR can offer proactive solutions to its customers and enhance their experience. Moreover, EMR promptly notifies its customers of any problems and offers solutions to help them resolve issues quickly and efficiently.

EMR continuously develops new products that cater to its customers'

needs, such as symmetrical speed upload and download 1:1, unlimited data usage, and 100% fiber-optic connectivity.

To further enhance the user experience, EMR is exploring other new technologies, including artificial intelligence and machine learning. These technologies can assist EMR in analyzing customer behavior and predicting their needs, enabling it to provide even better services and stay ahead of the competition.

EMR and ZTE cooperated on the fiber network construction in 2022. What do you think of ZTE's performance during the project and what's your expectation for ZTE in the future?

EMR highly values its partnership with ZTE in the fiber network construction for 2022. ZTE's performance has been fully supportive of EMR's vision to be a source of pride for Indonesia. In 2022, EMR successfully added eight new cities to its coverage area, and this year, EMR is continuing to expand its reach to more cities. EMR and ZTE are working together to develop new technologies such as DWDM technology, which aims to increase the bandwidth of existing fiber networks. Additionally, EMR is developing ROADM + ASON and high-capacity BNG to further improve the quality of its services. EMR is looking forward to building a strong relationship with ZTE and collaborating more in the future to establish more breakthroughs in infrastructure projects.

Where do you see the telecom industry going within the next few years?

EMR firmly believes that the telecom industry will continue to thrive and develop high-tech initiatives. With Indonesia's ongoing digital transformation and increasing digitalization among its people, the demand for high-speed internet connectivity is on the rise. This growing demand is also leading to increased market competition. However, EMR is confident that it can provide unlimited internet connectivity to meet the needs of both customers and businesses. In the coming years, the Indonesian government is expected to fully support the telecom industry to expand into underserved areas and contribute to the country's economic growth. Regarding technology, the market is expected to witness the development of FMC, 5G technology, and IoT.

In conclusion, with its unwavering commitment to providing quality internet services, emphasis on infrastructure expansion, and ability to adapt to evolving market trends and needs, EMR is well-positioned to flourish in Indonesia's telecom industry in the years to come. ZTE TECHNOLOGIES

5G+ Industrial Internet: Creating a New Era of Fully-Connected Factories

Wang Jingfei, Director of ZTE Wireless ToB Planning

Since 2020, the global deployment of 5G networks has been initiated. At present, there are more than three million 5G base stations built worldwide. Moreover, 5G networks have been widely adopted and implemented in important industries.

The industrial Internet is the central component among various elements in the application of 5G in factories. It directly serves the IT and OT business systems of enterprises, while the 5G network plays a crucial role in ensuring its smooth operation.

Great Challenges Faced by Industrial Internet in Rapid Deployment

Fueled by the surge of digital economy in recent years, the industrial Internet has experienced rapid development. However, as the industrial Internet expands on a large scale, certain challenges have emerged in its platform construction.

- Currently, the typical application of the industrial Internet primarily revolves around simple digital transformation, lacking a unified construction solution. This "single-point" service approach may exacerbate the creation of information silos within enterprise digital transformation. Moreover, traditional enterprises' IT and OT networks are constructed by different manufacturers and managed by independent departments, resulting in internal "walls". Consequently, the digital transformation of enterprises is still in its preliminary stage.
- At present, the industrial Ethernet continues to dominate the network infrastructure in the production domain of enterprises. However, the complex wired connections pose great pressures on network deployment and flexible transformation within these enterprises.
- Most enterprises are incapable of moving to cloud at the production edge. The more complex the process and scale of intelligent manufacturing, the greater the need for data integration and exposure among various systems. However, in the core OT domain of industry, the mainstream industrial control systems are currently incompatible and lack interoperability. For enterprises, the most valuable asset is data. The current state of

> The industrial Internet is the central component among various elements in the application of 5G in factories. It directly serves the IT and OT business systems of enterprises, while the 5G network plays a crucial role in ensuring its smooth operation.

Wang Jingfei

fragmented data makes it difficult for enterprises to accumulate digital assets, hindering process optimization and iterative improvements.

5G Empowers the Industrial Internet

The introduction of 5G offers effective solutions to the challenges encountered by the industrial Internet. In terms of connectivity, 5G simplifies the traditional five-layer architecture of the industrial Internet into three layers (Fig. 1), facilitating the integration of data silos. Regarding networking, the new 5G network architecture provides a level of reliability and stability on par with industrial Ethernet, ensuring seamless operation in the core OT domain of industrial production. Furthermore, 5G inherently possesses cloud-edge synergy capabilities, allowing enterprises to independently deploy applications and resolve the problem of fragmented data from industrial control manufacturers.

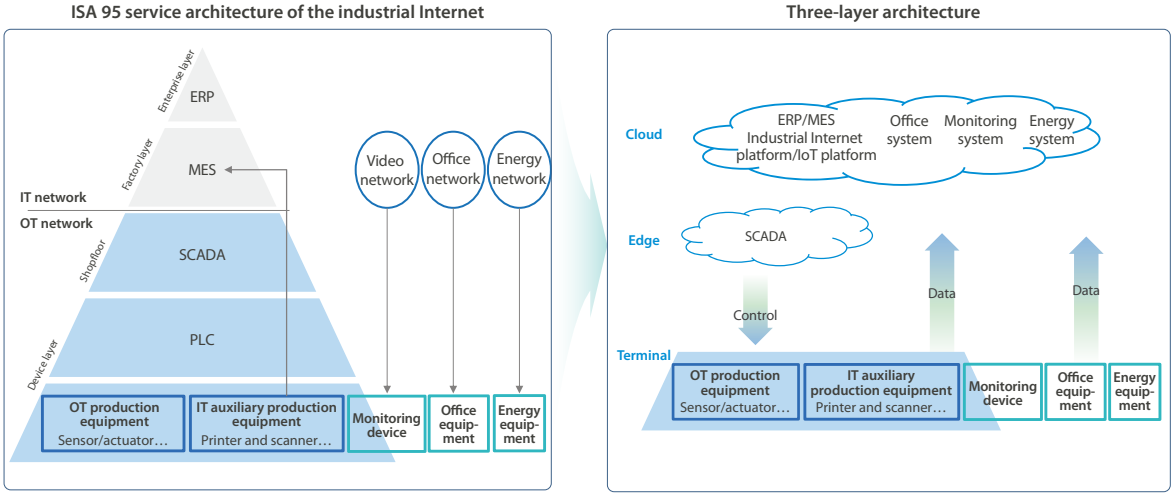
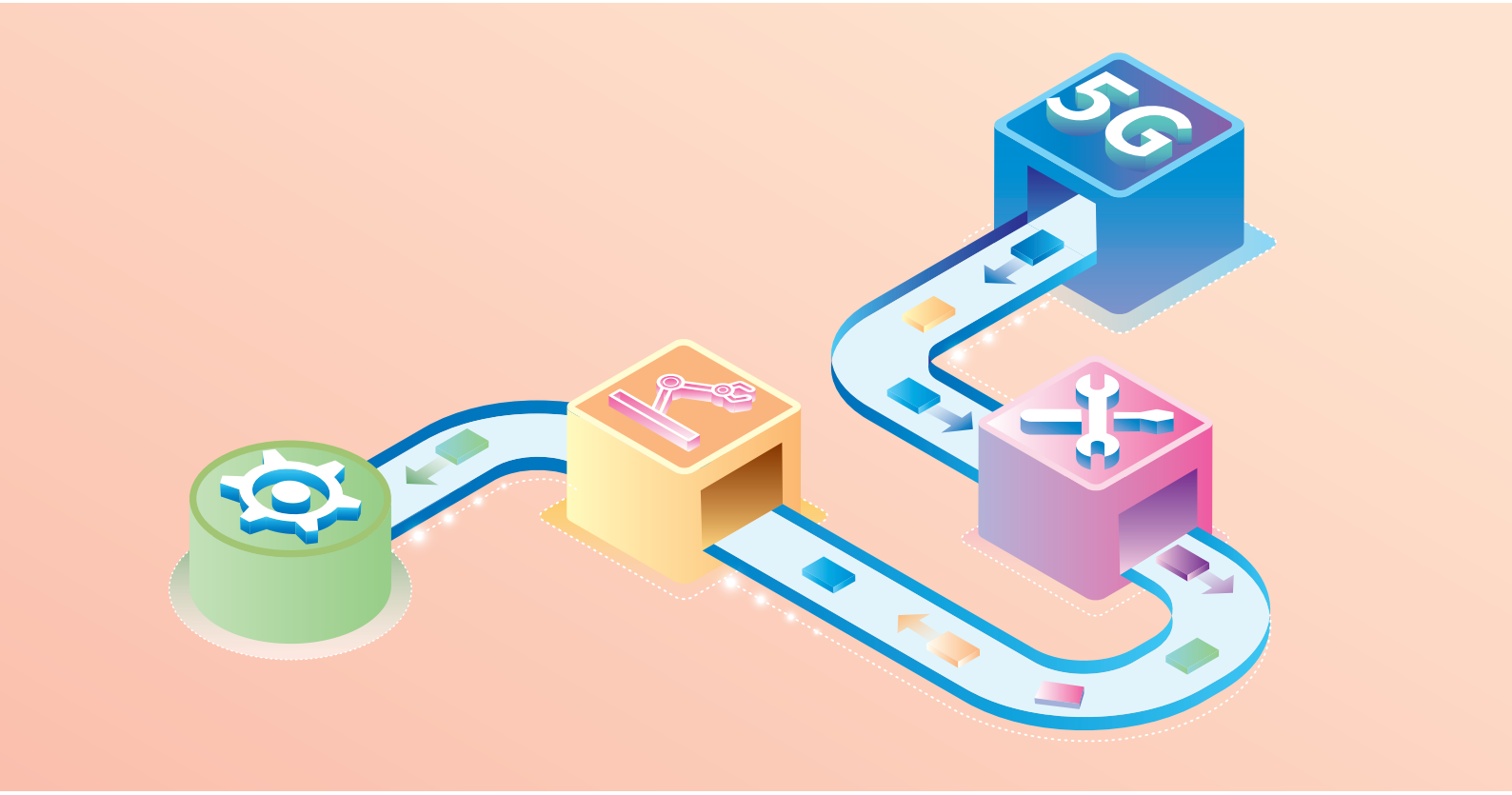


Fig. 1. The three-layer architecture of the industrial Internet.



5G Provides a Multi-layer Fully-Connected Network

In the network construction of traditional factories, the typical approach is to first establish a "campus network" at the factory level. This campus network serves to enable the factory's IT network and some production networks to move to clouds. It offers broad coverage and is often shared with public user networks.

As the connection field extends to the "shop-floor level" and "production-line level", the "campus network" based on the sharing mode is no longer applicable. The most important problems to be solved at the shop-floor and production-line levels are the reliable connection in the OT domain and the "field network" deployed with local computing power. Unlike the "campus network" that aims to solve all connection problems with a single network, the "field network" is customized for specific OT domain services. Therefore, there will be multiple customized "field networks" to accomodate different types of OT domain scenarios.

The 5G network provides abundant networking frameworks. For the "campus network", a networking approach compatible with the operator's network can be adopted, with UPF deployed inside the campus. For the "field network", an integrated hyper-converged networking mode can be used, and the networking is completed locally in the shopfloor or production line.

5G Provides Enhanced Flexibility and Reliability

Currently, there are three primary technologies used in the industry for industrial Internet communication

protocols: fieldbus technology, industrial Ethernet technology, and wireless technology. Comparing the three technologies, the fieldbus technology offers higher reliability, the industrial Ethernet technology has greater transmission rates, and the wireless technology provides a more portable and flexible deployment method.

The fieldbus technology is primarily used to support data communication between field sensors and controllers, between controllers and actuators, or between controllers and various input/output control stations.

The industrial Ethernet technology complies with the TCP/IP framework and offers advantages such as simple interfaces, open protocols, high reliability, fast transmission rate and convenient interoperability.

The wireless technology, represented by 5G, offers significant advantages, including the elimination of the need for power line deployment and the ability to connect to a greater number of monitoring and control points. 5G can be combined with time sensitive networking (TSN). When TSN is deployed between controllers and field devices, 5G enables high-quality deterministic delay transmission of control signals. When TSN is deployed between controllers, 5G achieves high-precision synchronous transmission of collaborative signals. When TSN is deployed between IT networks and OT network, 5G enables the uploading of production data to information systems and the distribution of control and management information to production equipment.

5G Computing Network Collaboration Provides Flexible Customization of Computing Power for Fully-Connected Factories

Thanks to network exposure, 5G networks inherently have collaborative computing capabilities across cloud, edge, and terminals. While investing in the construction of a 5G network, industrial enterprises can also deploy computing power close to their production sites. The enterprises can flexibly configure the computing resources of 5G networks according to the specific needs of different scenarios such as “factory-level” and “shop-floor + production-line-level”. By deploying the most suitable service systems nearby, they can minimize the delay loss caused by network detour. At the same time, the edge computing power is deployed within the enterprise campus, which falls within the domain of enterprise management. This enables unified management of computing resources and upper-layer applications in accordance with the enterprise’s security policies, effectively reducing data security risks.

With the flexible computing capabilities in the industrial Internet, enterprises will have more choices for their core business in the OT domain. They are no longer limited to traditional closed system solutions offered by industrial control enterprises. Instead, they have the opportunity to embrace emerging open system solutions, continuously accumulating production data and driving ongoing optimization and efficiency improvements.

Conclusion

As one of the global leaders in 5G networks, ZTE has worked with more than 90 operators and 500 partners worldwide to drive innovation and explore a wide range of 5G applications. It has accumulated numerous successful use cases in various industries. In the era of digital transformation and the construction of 5G fully-connected factories, ZTE has always been a powerful partner for operators and industry enterprises. ZTE TECHNOLOGIES

1+N Solution Extending 5G from Campus Network to Field Network

Ni Yanzi

ZTE RAN Product Solution Director

Shu Yu

Chief Expert of ZTE Wireless Industry Solution

Industry is not only the major force of the national economy, but also the foundation of social economic development. In recent years, China has been proactively promoting the integration of 5G and industrial Internet. The 5G industrial Internet has gradually become an important pillar for China's new industrialization.

After years of exploration, ZTE has released the 5G solution called "1 campus network + N field networks" which aims to integrate 5G applications into the domains of manufacturing and operation. This solution supports the construction of 5G fully-connected factories covering campus network, shop-floor network and production-line network, facilitating the expansion of the 5G industrial Internet.

Why We Need the 5G Field Network

Various industries, including steel-making, mining, port, metallurgy, and manufacturing, are actively pursuing digital transformation, guided by the forerunner enterprises. For example, in the steel-making industry, there has been an increase in investments for informatization, digitalization and intelligence with more than 80% of China's steel-making enterprises promoting intelligent manufacturing.

China keeps promoting the transformation of traditional industries, and the Chinese Ministry of Industry and Information Technology, along with multiple departments, has launched policies such as the 5G Application "Sailing" Action Plan, 5G Industrial Internet Promotion Plan, and 5G Fully-Connected Factory Construction Guide. The aim is to extend the 5G industrial applications from peripheral activities to core production activities and promote the industrial transformation.

5G, as a wireless technology, will be gradually introduced into the production domain. For industry customers, the high performance and wireless features of 5G will fundamentally change their working modes, facilitate elastic production, and unlock potential benefits in multiple aspects such as production capacity, revenue, manpower, and security. Deeper integration of 5G into

operation domain will bring greater value for operators and increase user stickiness.

Whether the 5G campus network could fulfill the field applications? Actually, field applications have three unique demands. First, they have extreme requirements for determinism. The existing performance capabilities of the campus network depend on the public network, making it difficult to apply various strict assurance measures. Second, field applications need closed-loop data. That means the generation, receiving and processing of data must be closed-loop on the field to ensure continuity and security. However, the campus network relies on remote public clouds or is closed-loop at the campus level, making it challenging to match local close-loop requirements. Furthermore, some field networks, especially production-line network, need to be pre-integrated by integrators in advance. The campus network serves multiple services and even public subscribers, so it can't match the pre-integration and migration requirements of production lines. Therefore, serving field applications directly using the campus network is difficult. To better serve the manufacturing process, we recommend overlaying field networks on the basis of a 5G campus network, i.e., a"1+N hierarchical 5G private network" (Fig. 1) .

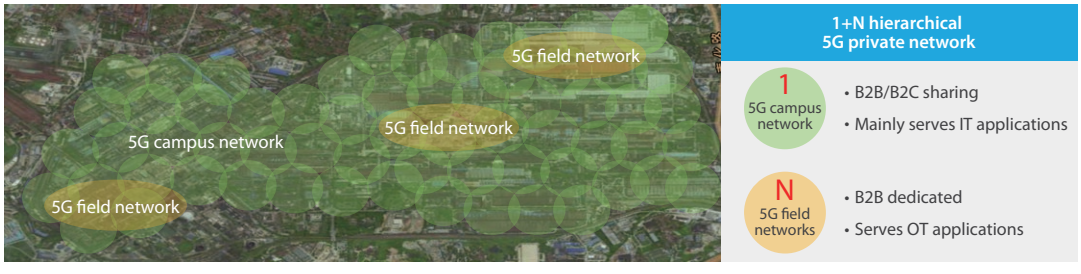


Fig. 1. 1+N hierarchical 5G private network.

Core Requirements and Challenges of the 5G Field Network

Traditional industrial control networks connect all devices through wired networks, such as industrial Ethernet and field buses, with programmable logic controller (PLC) at the core. However, this presents several challenges for the digital transformation of the industrial control network. First, wired networks are difficult to deploy and prone to failures, which don't allow the production lines to make quick adjustments, resulting in low flexibility and hard service upgrades. Additionally, the traditional PLC ecosystem is closed, and regular upgrades of software and hardware can be costly.

We have implemented 5G digital transformation in many industries. For example, in a steel-making enterprise's crane scenario, 5G is utilized to support wireless PLC northbound connection between the unmanned crane and its control system. This allows convenient deployment of the crane while avoiding many hidden troubles and fault points caused by moving cables. In an automatic logistics sorting scenario, a large-scale automatic control center requires the cooperation of PLCs with thousands of I/O points. By using 5G technology, the master-slave PLC system can be connected wirelessly, greatly simplifying the cable deployment and facilitating the upgrade of the automatic logistics sorting system. Furthermore, in 3C electronics manufacturing where elastic production is a significant requirement, 5G technology can be used to enable wireless PLC southbound connections between the PLC and the end equipment, enabling flexible and elastic production.

After analyzing typical field network scenarios, we've found that using 5G to serve the field applications should be done step by step, and there are three top challenges to be addressed when implementing 5G field networks.

- **Difficulty in performance guarantee:** With 5G-driven cord-cutting, the deterministic requirements have become higher and higher. For example, the southbound communication of PLC requires ultra-low latency assurance.
- **Requirement of cloud, network and applications:** Applications are key to digital transformation of industries. How can we easily deploy all kinds of applications? We need to take into account cloud platform and applications besides the 5G network.
- **Complex network O&M:** Although 5G provides convenience to applications, traditional 5G networks are really complicated for enterprise self-O&M.

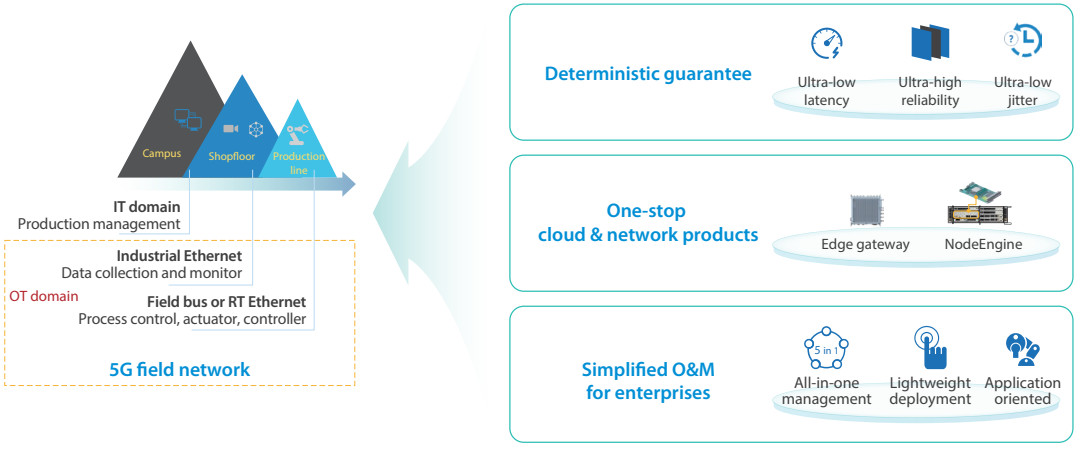


Fig. 2. Three key capabilities of 5G field network.

Three Core Capabilities for ZTE 5G Field Network

After extensive practice, ZTE has proposed three key capabilities of 5G field network: deterministic guarantee, one-stop cloud-network solution, and simplified O&M for enterprises (Fig. 2).

Deterministic Guarantee

For common applications of 5G field network such as data collection, AGVs and PLC northbound, deterministic requirements of 20 ms@99.99% are typical. To meet these requirements, it is recommended to use network enhancements such as local traffic offloading and frame replication and elimination for reliability (FRER) to improve network capabilities. In addition, features such as short SR period, intelligent pre-scheduling and low MCSs can be introduced to improve the air interface capabilities. To accurately guarantee different applications, precise service identification, scheduling and KPI measurement can be used.

As 5G cord-cutting continues, latency requirements become higher, less than 10 ms@99.999% for applications like PLC southbound, along with strict jitter requirements. For these services, URLLC technology needs to be introduced to provide ultra-low latency and ultra-high reliability, and TSN technology also needs to be introduced to guarantee jitter as low as 1 ms.

One-Stop Cloud-Network Products

Applications play a key role in the digital and intelligent transformation of industries. To achieve flexible, convenient, and low-cost deployment of various industrial applications, cloudification is currently the trend. That means cloud, network, and industry applications should be taken into consideration during transformation. For this purpose, ZTE provides one-stop cloud-network products for 5G field network, so that computing power can be extended from the campus network to the field network, enabling on-demand deployment of applications. On the edge side, ZTE provides the industry-only site-level computing engine, NodeEngine. By inserting the computing engine board into BBU, ZTE can rapidly upgrade the common base station to the computing base station to implement local traffic offloading and local application deployment. This helps to integrate 5G base stations with industrial applications. On the terminal side, ZTE has launched a series of 5G edge gateways that provide not only abundant interfaces for interconnection with various industrial devices but also built-in computing platforms for applications such as video coding and PLC control.

Simplified O&M for Enterprises

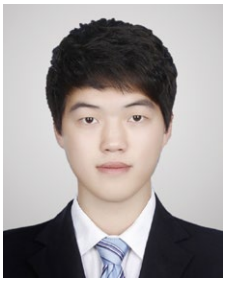
To reduce the barriers of applying 5G to vertical sectors, ZTE has developed a series of features that greatly simplify O&M for enterprises. These features include an all-in-one management system that provides end-to-end management capabilities across wireless network, core network, bearer network, fixed network, and terminals, and the self-service IDOS portal that enables enterprises to monitor and manage the applications independently.

By working with operators and industry partners, ZTE has gotten rich experience in building 5G fully-connected factory in industries such as manufacturing, logistics, ports and mines. Leveraging its innovative 5G industrial Internet integration capabilities, ZTE will continue to empower the intelligent transformation and upgrade of China's manufacturing industry. ZTE TECHNOLOGIES

5G Field Network Solution Enabling Digital and Intelligent Upgrade of Industrial Manufacturing

He Jiqing

Wireless ToB Integrated Solution Director, ZTE



Wei Li

5GC ToB Planning Director, ZTE

In the past decade, China has made significant progress in intelligent manufacturing, but most enterprises are still in the early stage of transformation towards intelligence. At the end of 2021, the equipment networking rate of industrial manufacturing enterprises in China was only 28.78%, the automatic data collection rate for production was 40.1%, and the full-process quality traceability was only 16.97%. A large number of production elements such as personnel, machinery, materials, methods, environment, and measurement have not yet been interconnected. To achieve the networking of a large number of dumb devices on the production site, significant changes are required for the existing industrial Ethernet and field buses based on wired technology. These changes involve adding ports and devices, rewiring, and reconfiguration, which entail a large and complex workload, a long cycle, high costs, and a significant impact on production.

However, by seamlessly integrating 5G field networks with existing industrial networks, intelligent upgrading and transformation of industrial enterprises can become smoother, faster, lower-cost, and more efficient in operation.

What's 5G Field Network

5G Field network refers to a 5G network deployed in production sites such as production lines and shopfloors, connecting production elements of people, machines, materials, methods, environment and measurement to achieve local real-time closed-loop processing of applications in core production domain such as data acquisition, industrial control and production management. This network is also integrated with operational, information and communication technologies (OICT). As the application of 5G in the industrial enterprises has gradually expanded from peripheral production assistance to core production control, the 5G field network will accelerate the pace of 5G deep into the core production control and make industrial manufacturing flexible, digital and intelligent.

Solution

Taking into account the industry characteristics such as local real-time closed-loop processing of OT business flow in production lines or shopfloors, short production cycle, automatic connection of process flow, and frequent adjustment of flexible manufacturing lines, ZTE has developed a 5G field network solution that integrates terminals, network, cloud, applications and maintenance (Fig. 1). This solution provides a one-stop, low-latency, low-jitter, and high-availability deterministic wireless network for the core production business, meeting the needs of flexible, digital and intelligent upgrade of industrial manufacturing.

The 5G field network offers the following benefits:

- **Cloud-network integration and local closed-loop of business operations:** Industrial dedicated i5GC, 5G industrial base station,

and intelligent 5G industrial gateway are based on the carrier-grade TECS Cloud Foundation (TCF), supporting on-demand deployment of third-party industrial applications such as manufacturing execution system (MES), warehouse management system (WMS), supervisory control and data acquisition (SCADA) and cloud-based programmable logic controller (PLC). The 5G field network achieves the shortest path and optimal architecture from production devices to the platform, deeply integrates with OICT, and creates a closed-loop of business operations between production devices.

- **Native deterministic network capabilities:** The 5G field network natively supports end-to-end deterministic network capabilities such as URLLC enhancement, 5G LAN, time sensitive network (TSN), frame replication and elimination for reliability (FRER), board/NE/link backup, and high-precision indoor positioning. It can provide a deterministic performance guarantee for core production operations such as industrial control.
- **Lightweight equipment and simplified networking:** The lightweight 5G core network i5GC is based on carrier-grade 5GC and only includes essential 5G network functions. It adopts a unified virtualized network function (VNF) design and simplifies the internal communication mechanism, requiring only a single server at its simplest configuration. The industrial base station and intelligent industrial gateway achieve high integration, hyper-convergence, and industrial-grade high reliability. With end-to-end 5G LAN Layer 2 communication capabilities, the 5G network provides simplified networking where "devices hop onto the platfrom" without the need for deploying and configuring tunnel devices, seamlessly connecting or smoothly replacing traditional wired production networks.
- **Multi-protocol one-stop access:** The industrial-grade intelligent 5G industrial gateway SmartEdge 6100 supports rich access modes such as RS-485/232, CAN, Ethernet or WiFi, as well as a variety of industrial protocols such as CANBus, Modbus, EtherCAT, OPC UA, and S7 Comm, which can seamlessly connect with different types of industrial equipment.
- **Free from planning, debugging and O&M:** Customers can be free from network planning through 3D laser environmental survey, 3D modeling and business-oriented network pre-planning. They can be free from network debugging through factory pre-installed software version, out-of-the-box on site, one-click modification, and hour-level commissioning. They can also be free from network O&M through service-oriented terminal and service supervision, visual presentation, automatic maintenance and optimization.

Application and Practice

The 5G field network solution is applicable to the construction of 5G fully-connected factories

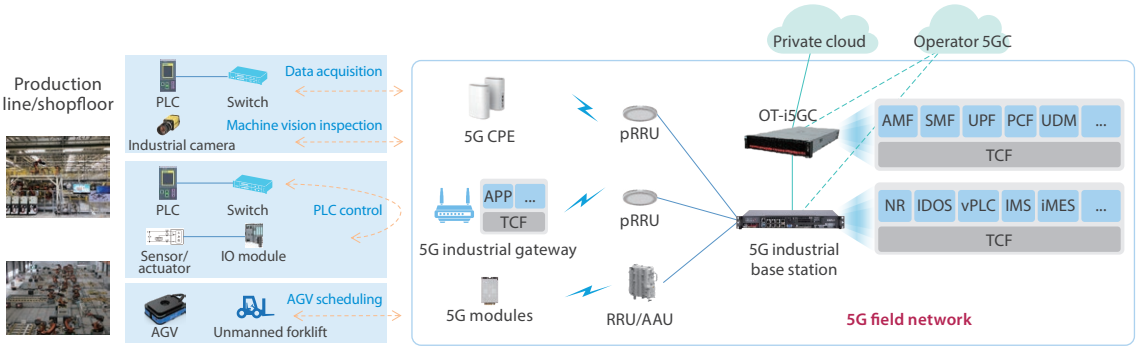


Fig. 1. 5G field network solution.

at the production line/shopfloor levels. It focuses on operational technology (OT) domain applications in industrial production, achieves ubiquitous connectivity of production elements and deep integration of OT and IT, and empowers digital and intelligent transformation of industrial manufacturing. ZTE, together with telecom operators and industry partners, has carried out extensive practice in the field of industrial manufacturing.

Full-Lifecycle Service

A production line integration and service provider for certain equipment manufacturing deploys ZTE's 5G field network solution on the production line of its end customer. The 5G field network can connect equipment on the production line, collect equipment data in real time, and provide full-lifecycle service including production line assembly and debugging, operation management, efficiency management, energy consumption management, predictive maintenance, and health assessment based on ZTE's self-developed intelligent manufacturing data service platform. In addition to low-latency high-reliability end-to-end deterministic capabilities, the 5G field network also provides computing power and deployment environments for data acquisition and intelligent manufacturing data service platform, thus achieving all-in-one deployment of production, network and applications, IT/OT integration, and local real-time closed-loop of business operations in production lines.

Centralized Control

A logistics automatic sorting line provided by a logistics automation equipment and system integrator to its customer includes more than 20 PLCs and several industrial control servers. The master PLC of the line body and the slave PLC on the sorting trolley communicate in real-time through WiFi and leaky-wave cables, resulting in poor stability, high cost and difficult maintenance. When using the 5G field network, master PLCs of the line body are cloudified and deployed on the industrial base station, while slave PLCs on the sorting trolley are cloudified and deployed on the intelligent 5G industrial gateway. Through 5G, the master and salve PLCs can communicate in real time. Therefore, centralized control of multiple PLCs can be realized on the cloud and a large number of PLCs and industrial control servers are saved. This reduces costs and improve reliability.

Automatic Production

ZTE Nanjing Binjiang Factory has built its 5G QCell production shopfloor based on the 5G field network. The 5G QCell production shopfloor has achieved automated production from raw materials to finished products. It reduces labor costs, increases the product qualification rate, and improves production efficiency. Its main application scenarios include 5G-based GV, 5G-based machine vision, 5G-based SMT, 5G-based data acquisition, 5G-based cloud PLC, and 5G high-precision indoor positioning.

ZTE's 5G field network solution is specially designed for 5G to enter the core production process. It features lightweight and simplicity, cloud-network integration, native determinism capabilities, and customer self-service. As a cloud-network base, it supports the comprehensive connection of production elements, production links, and business processes. It is a preferred solution for the construction of 5G fully-connected factories in production lines/shopfloors, enabling digital and intelligent upgrade of industrial manufacturing. ZTE TECHNOLOGIES

5G Industrial Base Stations: Empowering 5G to Reach Deeper into Industrial Production

Li Yunhua

Chief Planning Engineer of RAN Product, ZTE

With the deepening application of the "5G+ Industrial Internet", 5G networks are playing an increasingly important role in enhancing the efficiency of traditional manufacturing and implementing the digital transformation of manufacturing. The 5G+ Industrial Internet has become an important force to promote the digital, intelligent, and green transformation of the industry.

In the current phase, 5G has moved from being used as an industrial campus network solution for auxiliary production to becoming an industrial field network solution for production line operations. Industry customers are integrating 5G into on-site production process control and have suggested centralizing the production line control rooms and moving them off-site, as well as using wireless PLC controllers to eliminate the need for cords. While the upper computer is moved up to a centralized place, the data will stay within the shopfloor or factory. This requires the 5G network performance to be comparable to that of the wired network, which places new requirements on the 5G network, including deterministic connection, reliable guarantee, coordination between the network and industry service, and integration of the computing resources.

To meet these requirements, ZTE has proposed the NodeEngine-based industrial base station solution. This solution, based on the basic network connections of the traditional base stations, provides enhanced assurance of deterministic connection capabilities, making it possible for 5G to penetrate into the operational technology (OT) domain of the industrial production line. It also provides capabilities such as simple commissioning, flexible network architecture, and integrated virtual PLC to ensure the value investment.

5G Industrial Base Station Solution

To meet the wireless and centralized requirements of the PLC in industrial production lines, the 5G industrial base station provides a cloud-network integrated base station solution. With a computing board added to the traditional base station, it provides functions such as precise clock synchronization, enhanced connection capabilities, deterministic delay guarantee, and support for centralized and cloud-based PLC. In addition to traditional base station functions, 5G industrial base stations offer four key features:

- **Intrinsic determinism: Provides punctual and accurate data transmission services**

Intrinsic determinism means the ability to provide punctual and accurate data transmission services between industrial base stations and 5G industrial CPE. This is achieved by integrating various technologies with the 5G air interface enhancement technology, such as clock synchronization for terminals and networks, precise gate control for jitter elimination,

frame replication and elimination for reliability (FRER), PLC packet priority and scheduling timing orchestration, and mapping packets with different priorities to TSN priorities. To ensure latency performance, several techniques are introduced such as mini-slots, DS frame structure, URLLC service preemption, uplink pre-scheduling, SR period parameters, and DRX function. Moreover, a series of enhanced designs are performed on the 5G air interface to trade redundancy resources for high reliability. For instance, control channel enhancement, low CQI/MCS table, and repeated transmission are introduced at the physical layer to improve fault tolerance of modulation and demodulation, and reliability of data transmission, and PDCP replication is introduced at the PDCP layer to improve data redundancy.

- **Reliable autonomy: Improves data transmission reliability**

For 5G networking in industrial fields, dual-module connections are established through industrial CPEs while dual-frequency networking is used between industrial CPEs and industrial base stations. The FRER technology is enabled to greatly improve data transmission reliability. In addition, industrial base stations also provide "isolated site autonomy", which allows existing services to operate normally when the control plane of the base station is disconnected from the 5GC core network.

- **Network-service collaboration: Enables the network to coordinate and adapt to services**

On the industrial sites, there are various service scenarios, such as PLC control, AGV transport, machine vision, and data collection, which involve many service types that vary greatly. To ensure a refined guarantee of services in the wireless network, it is necessary to understand the service features and the requirements of each service for network transmission.

Industrial base stations have the capability of "accurate identification". By introducing the AI algorithm and analyzing data streams, these stations can dynamically identify service types and automatically match them with the requirements of QoS templates. Characteristics of the service flow may be further identified, such as the survival time period of the PLC service, the I frame and the P frame of the video service flow, and the size, period, and arrival time of the packet. These features can be combined with air interface scheduling technology for refined processing. This elevates the control from the traditional service flow level to the service packet-level granularity, enabling the network to coordinate and adapt to services and achieve the precision effects.

- **Computing and network integration: Centralized and cloud-based PLC computing power sharing platform**

In traditional industrial production lines, a physical PLC acts as a bridge between application systems such as device data and IT network information processing, and plays a crucial role in data structuration and logic control. However, this approach has some disadvantages. First, the protocols between PLCs of different manufacturers are not open, which poses challenges to the coordination and extension required by software-defined flexible manufacturing. This requires an upgrade to the application system, resulting in latency and service reliability problems. Second, the private fieldbuses of different vendors are incompatible, making interconnection inconvenient, and the field device layer is tightly coupled with the PLC, increasing the operation and maintenance costs for enterprises. Finally, the digital and intelligent transformation of enterprises requires on-site network intelligence and big data. Traditional PLC devices cannot

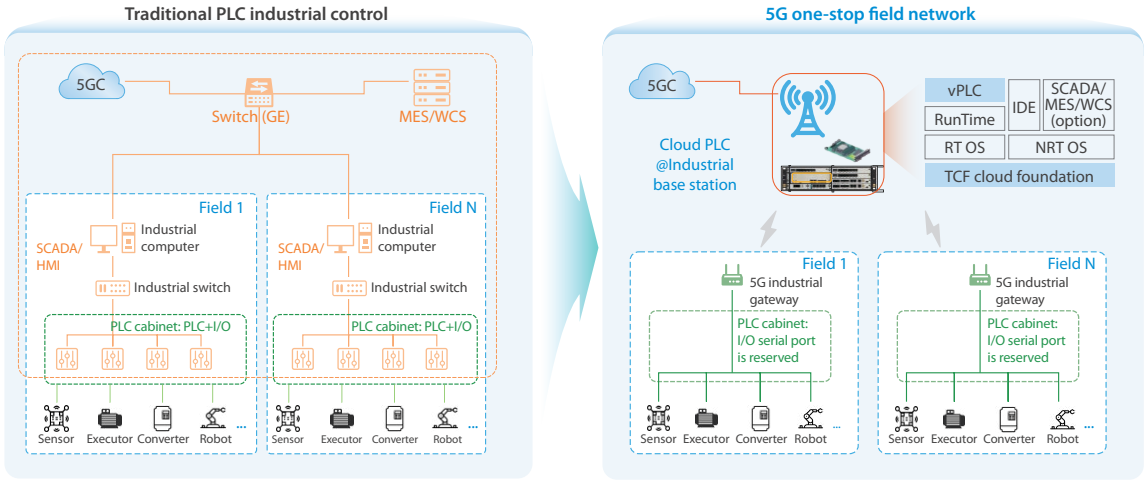


Fig. 1. Industrial base station solution diagram.

support visual data processing services. At present, the machine vision services in the on-site network require the addition of dedicated industrial computers and servers, resulting in the complexity of on-site networking.

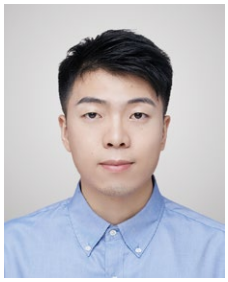
To address these issues, industrial base stations provide an integrated computing and network solution that decouples the computing and I/O of PLCs through the virtualization technology (Fig. 1). This allows the PLCs, machine vision, big data, and other services to share the computing platforms based on general hardware computing power. Additionally, the PLC IO function can be extended to the industrial gateway, which, together with the intrinsic determination capability of industrial base stations, normalizes the IT and OT networks to achieve flat networking on the site. This facilitates collaboration and interaction of on-site devices, achieving multi-service integration and collaboration.

Conclusion

Driven by policies and technologies, there is a growing trend towards the convergence and normalization of OT and IT in the on-site network field. ZTE's 5G Binjiang Factory in Nanjing has been exploring the application of the 5G industrial field network solution in intelligent manufacturing. On the QCell assembly line, an on-site network service platform has been built using the industrial base station solution and the 5G industrial gateway. This platform enables unified access management of southbound devices and buses in the OT domain, and IT services such as virtual PLC runtime environment and computer vision detection. This platform also provides machine vision applications, including the logic control of the manufacturing line and electronic fence, as well as northbound data interface services.

The 5G industrial base station solution makes full use of the benefits of 5G networks and address issues such as many layers of industrial Ethernet networks, many fault points, and service adjustment difficulty. This solution enables wireless PLC and allows production control to shift from PLC local multi-point, and discrete management to centralized and integrated management. It facilitates the transition of business logic from the non-compatible and closed ecological mode of traditional PLC manufacturers to the software-based and open ecological mode of cloud-based PLC. Thus, the industrial site network evolves from silos and OT local control to OICT integration that allows for flexible manufacturing and digital and intelligent production. ZTE TECHNOLOGIES

Mini5GC Helps Core Production in OT Domain Through Scenario-Based Application of 5G Private Networks



Li Chunfeng

Private Network Product Planning Manager, ZTE

With the large-scale deployment of 5G networks and the commercial use of new 5G technologies, 5G plays an increasingly important role in enabling digital transformation of industries, and the development trend of private 5G networks is becoming clear. 5G has become a core driving force for industrial digital transformation and "digital and intelligent" social transformation in the industrial, government and enterprise, and intelligent production fields. The implementation of private network products has cleared the barriers for digital transformation of operators and enterprise customers, and has become the core means of empowering the production field with 5G.

ZTE's private network and core network continue to evolve. With the combination of technological innovation and commercial implementation, ZTE has launched a series of private network and core network products. It has rolled out general iCube to meet the needs of integrated cloud, network, and service and maintenance, and has developed standard i5GC for private 5GC networks. The entire 5GC network can be deployed on a single 2U server. In October 2022, ZTE launched Mini5GC—an ultra-light CN product for extreme scenarios such as oil and gas exploration, emergency rescue, and explosion isolation in mines. Mini5GC features ultra-small and ultra-light design, ultra-simple networking, and ultra-high integration.

Mini5GC has two attractions. First, it has a highly streamlined architecture and is easy to build. Through the integration of general network functions, network communication and resource occupation are optimized, so that a lightweight 5G core network can be deployed on one 1U server. The size of the server is reduced to that of A3 paper, the weight is reduced to 5 KG, and the power consumption is 100 W. There is no special requirement for power supply of the equipment room, so the server can adapt to any rack in the equipment room. Mini5GC is highly integrated and has the highest performance of the same size in the industry. It supports 2000 users and has a forwarding capability of 5 Gbps, which can be regarded as small in size but high in performance. Therefore, Mini5GC can be flexibly adapted to the needs of explosion-proof mining, flexible workstations and on-board deployment.

Second, Mini5GC can achieve integrated delivery of software and hardware, and rapid service provisioning within hours. It allows enterprises to customize functions on demand and enhance their determinism. The 5G LAN can be deployed on demand to support L2 Ethernet communication between industrial terminals. Mini5GC implements deterministic network forwarding and high-precision clock synchronization based on TSN, and achieves ultra-low-latency communication and ultra-high-reliability network transmission through URLLC and FRER. In addition, Mini5GC also provides more than 100 business templates for enterprises to choose and configure on demand. Through solidified configuration, the software and hardware are pre-integrated and installed before delivery.

The first call is connected, and the whole system is delivered from the factory. After arriving at the site, Mini5GC provides one-click configuration modification and automatic dialing test to realize rapid service provisioning within hours. Finally, Mini5GC provides local O&M and centralized O&M for enterprises to select according to their needs, freeing them from service operation and maintenance. Remote O&M can also be provided to monitor the status of the private network. Mini5GC can be deployed on the operator side or ZTE OpenLab to facilitate the professional O&M of private network and core network.

In addition to flexible networking of production lines in industrial shopfloors, ZTE Mini5GC can also provide core technologies for intelligent development of coal mines. It is applicable to the scenarios in mining areas such as high-definition video, unmanned driving, intelligent sensors, integrated voice, and inspection robots, meeting the requirements of network bandwidth, latency and reliability, as well as edge computing capabilities. Derived from ZTE's public network and core network products, Mini5GC has mature 4G/5G access functions and provides operators and industry users with deterministic network capabilities such as 5G LAN, TSN and URLLC to continuously empower the industry.

A coal mine in Shaanxi takes the lead in its intelligent transformation. Adhering to the concept of network-cloud synergy with the network as the basis and the cloud as the core, the coal mine works with ZTE to create an innovative intelligent solution for underground comprehensive mining work. They explore an effective development path for deep integration of 5G and smart mines.

The coal production process includes well construction, excavation, comprehensive mining, transportation and cleaning, and the working environment covers the upper and lower wells. The main difficulties are:

- The working environment is complex, dusty and watery. With limited underground space and frequent movement of large equipment, optical and copper cables are often scratched or damaged, which causes hidden dangers in production safety and affects work efficiency and transfer efficiency.
- Underground terminal devices are complex, including cameras, sensors, controllers, robots, wearable devices, and mobile phones. Their interface protocols are quite different, and there is no unified standard or platform for centralized access and monitoring.
- There are high security requirements. The production data shall not be out of the industrial park, and relevant underground devices have explosion-proof requirements.

ZTE uses Mini5GC to meet the special underground deployment environments and security and explosion-proof requirements. In this way, underground production data can be unloaded locally, video collection and personnel management data can be uploaded to the data center of the park, and the data can be connected to the underground voice system. All the networks in the park are managed in a unified manner and deliver the same service experience.

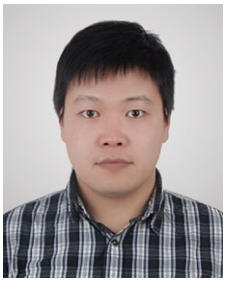
5G wireless transmission is an innovation in modern coal mining technologies. It helps to change workers' operating habits and improve their working environments. It is of great significance to improve the efficiency of comprehensive mining, reduce the number of workers and their labor intensity, and improve the intelligent mining capability.

Coal mine intelligence is the core technical support for high-quality development of the coal industry. This coal mine is super-large state-owned coal mine with a capacity of 10 million tons, and it is also one of the first batch of 71 smart demonstration mines in China. A set of Mini5GC is deployed under the mine to achieve full 5G coverage of the mining area, setting a benchmark for intelligent construction of coal mines and playing an demonstration role in the reconstruction coal mines across the country. This is a successful practice of 5G moving from supporting system to core operation, and it is also a solid step in the application of 5G private networks in industrial scenarios. ZTE TECHNOLOGIES

FRER Provides High-Reliability Service Guarantee for Determinism of 5G Field Network

Lu Zhien

ToB Architect of ZTE RAN Product Planning



Wang Zheng

5G Private Network Planning Director of ZTE CCN Products

The industrial field scenarios, such as metal processing, complex equipment assembly, and logistics bring a great challenge to timely and reliable acquisition of industrial equipment data like control and experience. Stable and reliable operation of field networks is very important for manufacturing enterprises to ensure stable production and improve the efficiency. Therefore, 5G networks should be capable of running continuously with high reliability for a long time after entering the OT domain of vertical industries. Most intelligent manufacturing facilities require the field network to operate steadily 24 hours a day and have a certain QoS guarantee, because any interruption will seriously affect normal operation of the enterprise.

To ensure end-to-end service determinism of 5G field network, a heterogeneous network can be deployed with redundant data transmission to achieve end-to-end high service reliability. Currently, there are two ways to enhance the reliability of data transmission: packet data convergence protocol (PDCP), and frame replication and elimination for reliability (FRER).

PDCP is used for redundant transmission of industrial data on different radio carriers. It supports carrier aggregation and dual-connection mode to reduce packet loss on the air interface caused by radio interference and ensure data integrity and timeliness.

FRER supports two modes: single-terminal dual-PDU sessions and dual-terminal FRER. Data is sent in redundancy mode through two independent user-plane bearer channels. The sender replicates data, and the receiver de-duplicates and reassembles data. This reduces service damage caused by packet loss in the transmission and core network and improves the reliability of end-to-end data transmission. Based on the reliability of existing terminals, ZTE uses its self-developed SmartEdge (SE) and NodeEngine (NE) to propose the SE+NE FRER solution. Through two independent radio links, FRER achieves optimal data receiving and forwarding at the convergence side. This not only avoids retransmission and even packet loss caused by occasional interference from the radio link on the air interface, but also avoids service interruption caused by sudden abnormality of a single UE. This solution can improve end-to-end service reliability.

FRER is applicable to control business in steel, port and mine with complex radio environments and high network reliability

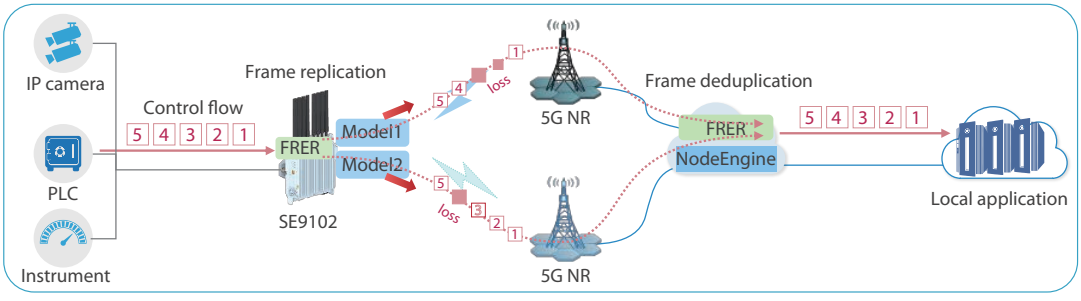


Fig. 1. SE+NE FRER networking architecture.

requirements. According to customer requirements and deployment patterns, ZTE has proposed three modes for FRER networking.

- **Mode 1: SE+NE FRER**

In the SE+NE FRER mode, uplink data is replicated through the gateway SE9102, transmitted separately through two 5G modules, and then converged, selective-received and forwarded at the NE side. After being duplicated on the NE side, downlink data is received, de-duplicated and forwarded by two modules of the gateway SE9102, as shown in Fig. 1.

In the unmanned driving project of a steel hot rolling factory, multiple dedicated PADs are deployed to build an independent inter-frequency physical dual-network in the 3.5 GHz and 2.1 GHz bands. The SE gateway is deployed for each travelling crane, and access control (one channel of PLC packets) and video data (two channels of HD IP cameras) are used together with NodeEngine to establish inter-frequency FRER channels. With the dedicated slices configured for control data and the EdgeQoS guarantee of NodeEngine, the delay effect of control data on the FRER channels reaches 20 ms@99.99%. Compared with a single-frequency network, the reliability of the inter-frequency dual-network is enhanced from 99.99% to 99.9999%, which helps enterprises achieve unmanned on-site driving.

- **Mode 2: SE+MEP FRER**

In the SE+MEP FRER mode, the FRER gateway function establishes tunnels with UPFs through internal ebridge modules of the MEC platform (MEP). The uplink data is duplicated through the gateway SE9102 and sent respectively through the two 5G modules. Convergence and selective forwarding are implemented at the MEP side. After being duplicated on the MEP side, downlink data is received, de-duplicated and forwarded by the two modules of the industrial gateway SE9102.

ZTE has participated in building a 5G smart factory for a large steel company in China. To extend coverage of the 5G private network, control-plane and user-plane NEs of the core network i5GC such as AMF, SMF, UDM and UPF are moved down to the branch area of the steel company. This meets the needs of 5G network application of the production control system such as smart molten iron transport, unmanned transport of finished hot-rolling products, driving positioning of travelling crane and intelligent warehouse management. In addition, a private dual-band wireless network (2.6 GHz+4.9 GHz) is built in combination with the SE+MEP FRER function to ensure that user services can satisfy network needs of high reliability and low latency.

- **Mode 3: SE+UPF FRER**

In the above two networking modes, NEs or MEC servers need to be deployed on the network side, which increases the deployment cost to some extent. Based on existing 5G network nodes, FRER can be built in UPF in the future, and the UPF+hot standby function will be implemented. When the active UPF fails, traffic will be smoothly switched over to the hot standby UPF, and UEs do not need to be offline. This solution is highly integrated, reduces external dependency, and decreases deployment costs. It also reduces the number of network nodes, simplifies the network and improves network reliability, which is applicable to the scenario where UPFs are moved to edge in the campus network.

FRER is one of the important solutions to ensure service reliability in the field of production control. It can be implemented in actual networks based on heterogeneous network architectures such as 5G+WiFi, 5G+wired, and 5G dual-band. The FRER redundancy transmission mechanism improves the success rate of end-to-end traffic data transmission and ensures the reliability of accurate data transmission and reception. This provides deterministic service guarantees such as delay, reliability and availability in ToB industrial application scenarios. FRER is therefore a complete service-based high-reliability solution. ZTE TECHNOLOGIES

5G Dual-Domain Private Network Solutions Facilitate Personalized User Access

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ToB Architect of ZTE RAN Product Planning

Lu Qiang

ZTE CCN Product Planning Manager

With the expansion of 5G private network services, various industry customers such as schools, governments, medical centers, tourist resorts and industrial parks hope to replace their existing Wi-Fi networks or deploy hybrid private networks using 5G. For confidentiality requirements of business data, these enterprises usually have their own intranet. When employees use personal mobile phones to access the enterprise's intranet through 5G network, they need to log in through a VPN or by other means, which can be quite complex and poses potential security risks. Therefore, it would be a great convenience for enterprise or campus users to use their personal phones with B2C SIM cards (personal phone cards) to access both the Internet normally and enterprise intranet in the campus without changing the SIM cards or phone numbers, while preventing data outflow.

For seamless access, a dual-domain private network is essential to provide enterprise private network access services for both B2B and B2C. This network enables seamless interconnection between the Internet and enterprise services for industry customers, facilitating the integration of B2C and B2B services.

Combining the Internet and enterprise service access requirements of industry customers, ZTE provides flexible 5G dual-domain private network solutions to meet the deployment needs of different application scenarios.

5G Dual-Domain Private Network Solution Based on ULCL

The ULCL-based 5G dual-domain private network adopts the uplink classifier (ULCL) offloading solution. It forwards uplink data traffic to different UEs as required by the filter, and combines downlink data traffic from multiple anchors of the UEs. The traffic is offloaded through ULCL. In this case, the primary anchor is located on the user plane function (UPF) of the public network, while the secondary anchor is located on the edge UPF of the campus. Local traffic within the campus is offloaded to the campus's intranet through the edge UPF.

An enterprise user first forwards data traffic through the public network's UPF. When the user moves to the campus, a TA update message is triggered and SMF sends a policy update request to PCF for event update. After delivering the policy update, PCF triggers a UL-CL procedure and an edge UPF is inserted into the original user session. In this way, the user session is distributed locally by the edge UPF, while any missed data is still sent back to the public network's UPF for processing, as illustrated in Fig. 1.

The ULCL offloading solution has the following benefits:

- Users in the campus can still use the

data network name (DNN) of a public network without terminal awareness, resulting in good user experience.

- Users in the traffic offload area (campus or home area) can access both the enterprise intranet and the Internet simultaneously.
- Users can continue to access the Internet while roaming without the need to route Internet traffic back to their home location.

There are also some constraints in the ULCL offloading solution:

- Campus services do not support access via 4G networks and roaming scenarios. Due to the lack of support for ULCL functionality in 4G scenarios and incomplete support in roaming scenarios in the 3GPP protocol, campus users are unable to access the enterprise intranet through ULCL while in 4G coverage.
- Terminals in the campus are planned by the operator as B2C users. Therefore, IP address conflicts may occur when interconnecting with the campus. To avoid conflicts, network address translation (NAT) isolation is required.

5G Dual-Domain Private Network Solution Based on NodeEngine

ZTE's NodeEngine-based 5G dual-domain private network solution is a simplified private network solution for campuses, hospitals and industrial parks. The solution can rapidly provide industrial private network services only by deploying one computing board in the existing BBU, which significantly reduces deployment costs and shortens deployment cycles.

By adding this computing board, the NodeEngine-based 5G dual-domain private network solution enables 4G/5G simultaneous access. The solution splits traffic based on the rules such as PLMN, S-NSSAI and destination IP addresses, and meets the access requirements of both 4G/5G B2B and B2C services, achieving the goal of keeping B2B traffic data within the enterprise campus and enabling B2C users to access both the Internet and the local enterprise intranet simultaneously (Fig. 2).

Delay Reduction and Service Experience Optimization

Compared to using a public VPN to access internal services such as industrial applications and online training, adopting the 5G dual-domain private network solution based on NodeEngine can greatly shorten the access path and reduce the service access delay. In addition, 5G realizes indoor and outdoor continuous coverage with larger capacity, stronger interference resistance, and better mobility. This one-hop direct access greatly improves service experience over traditional public VPN access.

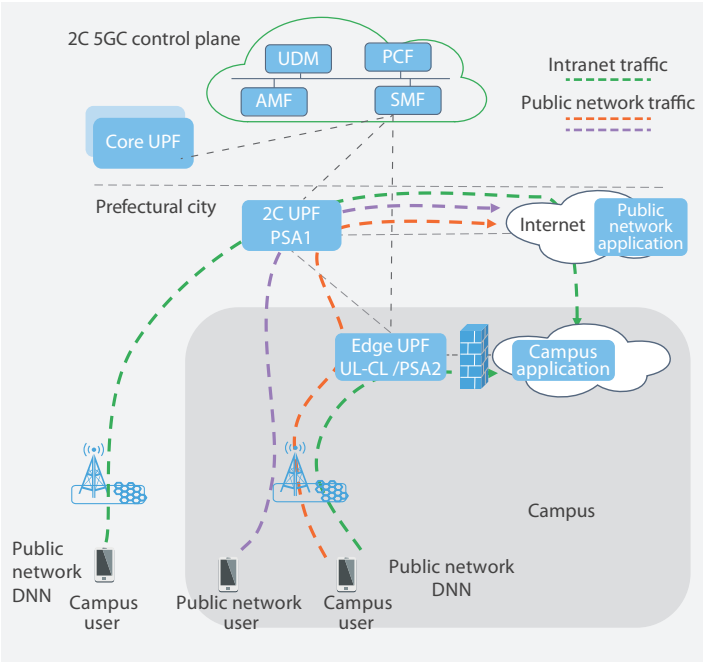

Fig. 1. ULCL offloading solution.

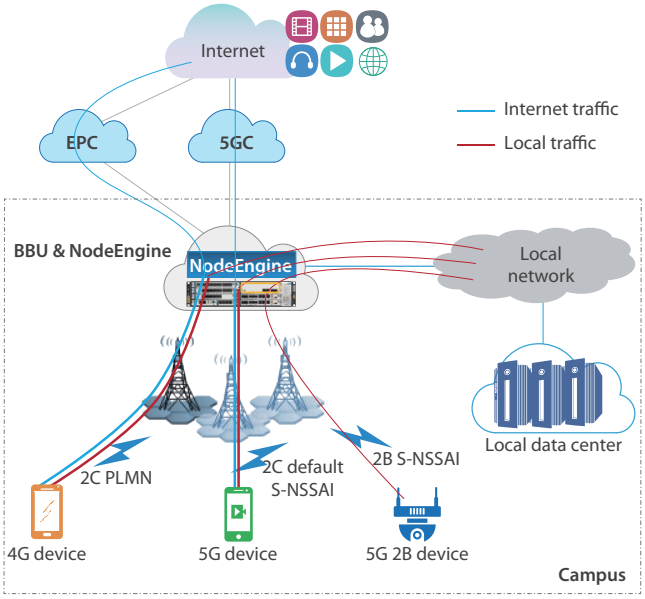

Fig. 2. 5G dual-domain private network solution based on NodeEngine.

4G/5G Multi-Service Integration with Local Access

A set of NodeEngine solution can support simultaneous 4G/5G network access and multi-service access to the enterprise intranet, satisfying the requirements of both mobile phones and B2B terminals and services. As a result, this solution meets the local access needs of existing 4G terminal users and protects the investment in 4G.

Seamless Offloading and Secure Control

The solution implements seamless data traffic divergence through one-phone-one-card access, allowing enterprise employees to simultaneously access the Internet and the enterprise intranet. The NodeEngine performs local traffic offloading and allows enterprise users to sign a specific RAT/frequency selection priority (RFSP). By identifying users with RFSP labels, it achieves synergetic access and effective management control for specific enterprise users on both public and private networks. Only signed enterprise users are allowed to access the enterprise's intranet services.

Applications

ZTE's 5G dual-domain private network solutions have been commercialized in several campuses and industrial parks. ZTE worked with a telecom operator to deploy the ULCL-based 5G dual-domain private network in a university in Wuhan in September 2021. Teachers and students can access both the Internet and intranet while on campus, and only the Internet when off the campus.

In August 2022, ZTE cooperated with an operator to deploy the NodeEngine-based 5G dual-domain private network in an industrial park in Inner Mongolia. A set of NodeEngine solution was used to enable simultaneous access of the 4G/5G private network and enterprise users in the industrial park. By signing a specific RFSP/SPID with enterprise users, employees in the park can access both the Internet and the intranet. When leaving the park, they can only access the Internet.

Summary

With the rapid growth of 5G and further improvement of infrastructure, the trend of replacing Wi-Fi with 5G in campus scenarios has become inevitable. Both ULCL-based and the NodeEngine-based 5G dual-domain private network solutions are designed to address the limitations of campus networks and enable access to 4G/5G-converged networks, expanding their application scenarios. As a leading global provider of integrated communications solutions, ZTE has been committed to proactively addressing customer needs and working with partners to constantly improve 5G dual-domain private network solutions. This will drive the deep integration of 5G+ industries, promoting the digital and intelligent transformation across various sectors. ZTE TECHNOLOGIES

5G Hybrid Positioning Solutions: Moving Towards Hazardous Scenarios

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Enterprise safety and production are closely related and inseparable, and safe production is the basis of enterprise development. Especially in the hazardous industries, there are many dangerous operating environments, such as furnaces and stockyards in steel plants, and flammable and explosive chemical installation areas. Accidents occur frequently, which cannot guarantee the safety of personnel, let alone safety in production.

To implement safe production and ensure the safety of personnel, it is necessary to make the location of personnel visible, hazardous areas manageable, and emergency response controllable. Many enterprises take safe production as their first priority, and begin to build a personnel positioning management system. Traditional positioning is mainly based on satellites, Bluetooth, UWB and other positioning technologies. Based on these positioning technologies, enterprises face the following problems in their choices:

- Satellite deteriorates its positioning accuracy due to obstruction, such as in the middle of multiple buildings or indoor areas of offices, factories, and shopfloors.
- Bluetooth and UWB have small positioning distance and need many hardware devices, resulting in high cost and complex maintenance. The construction in critical scenarios must be strictly approved, and it is difficult for on-site construction personnel to wire and obtain electricity, resulting in a long project construction period.
- Traditional Bluetooth, UWB and satellite positioning systems only focus on positioning capabilities, and cannot take into account the large-bandwidth wireless networks required for digital transformation of enterprises.

Facing the positioning requirements of critical scenarios, ZTE and upstream and downstream location service partners have insight into industry needs and scene characteristics, integrate a variety of positioning technologies, and build a 5G hybrid positioning solution based on 5G private networks.

As shown in Fig. 1, the 5G hybrid positioning solution is divided into four layers: terminal layer, network layer, platform layer, and service layer.

Regarding the terminal layer, where the measured object is

located, the portability is of primacy. ZTE provides a variety of 5G positioning terminals such as mobile phones and safety helmets with communication capabilities. It also provides card terminals adopting Bluetooth and UWB. With the launch of 5G RedCap positioning chips, more 5G lightweight, low-power and low-cost terminals will come out, and 5G positioning will adapt to more scenarios.

The network layer, which completes positioning measurement and provides the basis for location services, can be based on a variety of positioning algorithms of 5G cellular, and can also extend traditional positioning algorithms to adapt to various scenarios. For example, in chemical plant areas, steel factories and other steel-structure places, there are many large metal equipment and brackets; in this environment, the signal obstruction is serious, which has a great impact on positioning measurement. At the same time, there are many hollow areas, so vertical dimension should be taken into account in positioning. For various complex environments, positioning algorithms such as UTDOA, AOA and ECID are adopted based on 5G networks and the environmental characteristics. Considering both cost and accuracy, traditional positioning technologies such as UWB, Bluetooth and satellite can be integrated for specific areas. A variety of positioning technologies and algorithms work together to adapt to various scenarios, which provides a location foundation for the construction of enterprise personnel positioning management system.

The platform layer includes location-based service (LBS) and map service. LBS provides location calculation based on measurement data at the network layer, and also

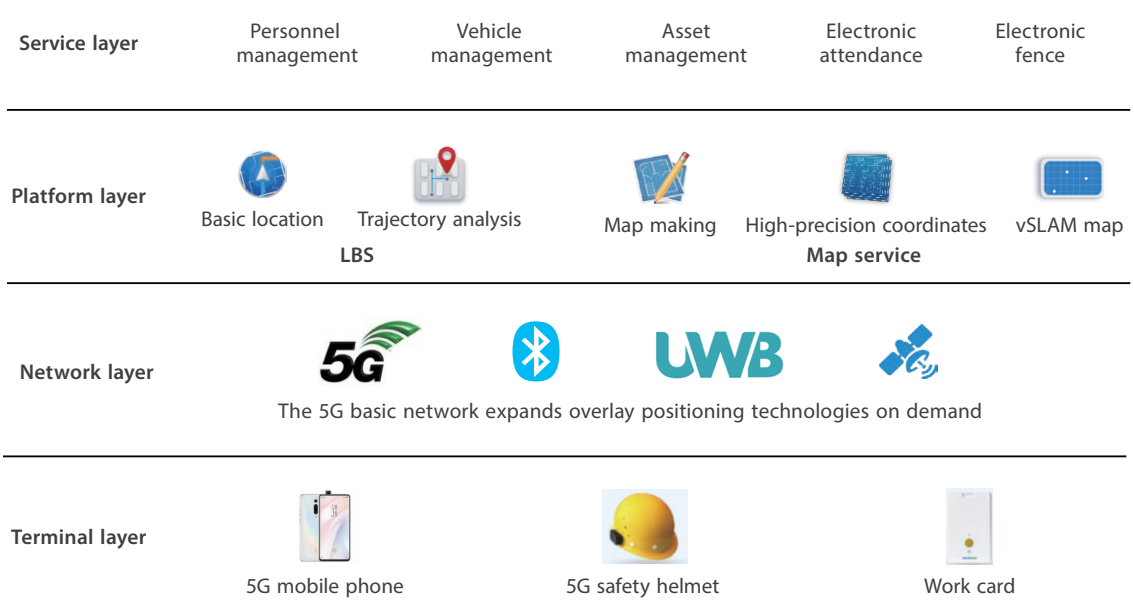


Fig. 1. Schematic diagram of 5G hybrid positioning solution.

provides basic location and trajectory analysis. Map service is used for closed parks or indoor places, providing map production rendering and location information presentation. It can choose centralized or distributed deployment methods according to the enterprise's existing cloud-edge architecture or its own distribution.

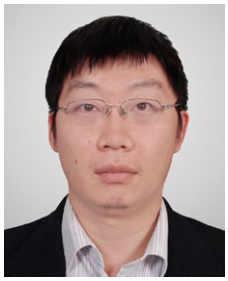
The service layer, which is the enterprise's service portal, provides enterprise-oriented application services, and is a part of the enterprise digital platform, including personnel management, vehicle management, electronic attendance, and electronic fence. It can also be combined with the digital twin technology to fully perceive people, equipment and environment, establish an efficient connection under the complex environment of the enterprise, and combine the operation of factory production system with the enterprise personnel positioning management system. The service layer and the platform layer are decoupled to be flexibly integrated. The digital platform of the enterprise can directly call the platform layer for application service presentation, or directly use the open location data of the platform layer to provide location services for the enterprise as required.

Enterprise-oriented location services need to consider map construction and end-to-end system integration, and also need to provide end-to-end positioning solutions in the fields of terminal, network, platform, map, and application integration, so as to ensure enterprises have a better service experience. ZTE has actively worked with partners to build and improve the solutions and gradually promote their maturity.

- **5G cellular positioning:** ZTE has completed end-to-end commercial trials of 5G cellular positioning technology in different scenarios such as industrial manufacturing, transportation hubs, chemical parks, and hospitals.
- **5G+UWB deep integration:** ZTE has carried out in-depth cooperation with industry-leading UWB enterprises, taking the lead in launching 5G+UWB deep integration solutions and promoting commercial trials and implementation.
- **Interface standardization:** ZTE has worked with industry chain partners to promote the standardization of location service interfaces, and has completed the integration with multiple business applications.
- **5G terminal form:** ZTE has promoted terminal partners to enrich 5G terminal types.

ZTE will continue to work closely with partners to further promote the development of the 5G end-to-end industry chain, provide all-scenario 5G hybrid positioning solution for complex and hazardous scenarios, and promote the rapid implementation of positioning management systems. The solution will become one of the strong supports for 5G-enabled vertical industries, empowering enterprise security management and facilitating their digital transformation. ZTE TECHNOLOGIES

"Digital Nebula" Boosts Digital Transformation of Industries



Cui Zhuo

Vice General Manager of ZTE Industry Digital Solution Dept.

Ren Jun

Architect of ZTE Industry Digital Solution Dept.

The wave of digital economy in China has led to an increase in the proportion of domestic industrial digitalization from 77% in 2016 to 81.5% in 2021. This highlights the growing consensus that digital transformation is indispensable for high-quality development of enterprises. However, compared with developed countries such as Germany where the proportion of industrial digitalization is as high as 91.3%, China has significant room for growth and presents great market prospects.

Challenges

In addition to the great development opportunities, China's industrial digitalization also faces huge challenges.

The first challenge is related to the understanding of digitalization and systematic top-level design. When enterprises are confronted with a large number of emerging technologies and production system innovations that differ from the legacy production processes, they have different perceptions of how to build digitalization and form a digital economy. This makes it difficult to form a systematic construction idea and top-level design.

The second challenge is to connect data silos. Enterprise digitalization requires solving the problem of data and capacity interoperability among multiple traditional isolated systems, and ensuring the long-term coexistence of the old information system with the new system during the transformation process. This makes it more difficult to support the inherently complicated reconstruction of enterprise information systems.

The third challenge comes from the ever-changing application requirements and inefficient development process. As we know, enterprise digitalization requires the development of a large number of new applications. The traditional development mode relies on professional software engineers, which are costly and time-consuming. It is hard to adapt to the changing business needs.

The fourth challenge is using new technologies and insufficient personnel capabilities. The rapidly evolving technologies have brought technical barriers to the digital transformation of enterprises. Cloud, big data, AI, blockchain, and other digital technologies are becoming more and more complex, which require a large amount of manpower and resources to master them. This further increases the difficulty of enterprise application development and the potential cost of exploring these technologies.

Digital Nebula Solution

ZTE has developed the Digital Nebula solution which is based on its accumulated experience in digital transformation and exploration in large enterprises, typical vertical industries, and complex urban

governance. As shown in Fig. 1, the solution is based on the cloud network technology and provides a complete set of tools and specifications that facilitate the digital transformation of enterprises. It also provides a systematic approach to the system architecture and evolution direction, serving as a reference for enterprises looking to embark on this journey. To be specific, the solution consists of four modules as follows:

- **Enabler:** covers full stack technology;
- **InOne:** integrates services;
- **Studio:** a development platform;
- **Market:** supports digital asset operation.

The Enabler integrates the technical capabilities of ZTE and its partners, including big data, AI algorithm models, XR engine, blockchain, and other industry leading technologies. It is designed to be open to enterprise application developers through standardized and easy-to-use interfaces, reducing the technical barriers and R&D costs of digital transformation, ultimately helping all industries achieve digital transformation.

The InOne is a digital bus that enables the convergence and opening of different types of digital assets such as data, capabilities and messages. It helps customers break through the information silos within the enterprise, realize the intercommunication between IT and OT, and between new and old application systems. It also realizes the convergence of IoT data and the entry of all kinds of application data into the data lake.

The Studio is a tool platform and R&D environment that improves development efficiency. It not only provides professional developers with a one-stop DevOps toolchain to improve development and O&M efficiency from the perspective of management, but also provides a variety of low-code development tools to upgrade ordinary business personnel to developers. This allows those who know more about requirements to rapidly develop enterprise applications by themselves and accelerate business innovations.

The Market provides enterprises with a unified portal for one-stop browsing, application, approval and activation of digital assets. It can achieve the largest range of controlled transactions with convenience and digital asset reuse within the company and among associated enterprises, improving the efficiency of resources utilization for enterprises.

Benefits

Enterprise digital transformation empowered by Digital Nebula can be characterized by four aspects: more, faster,

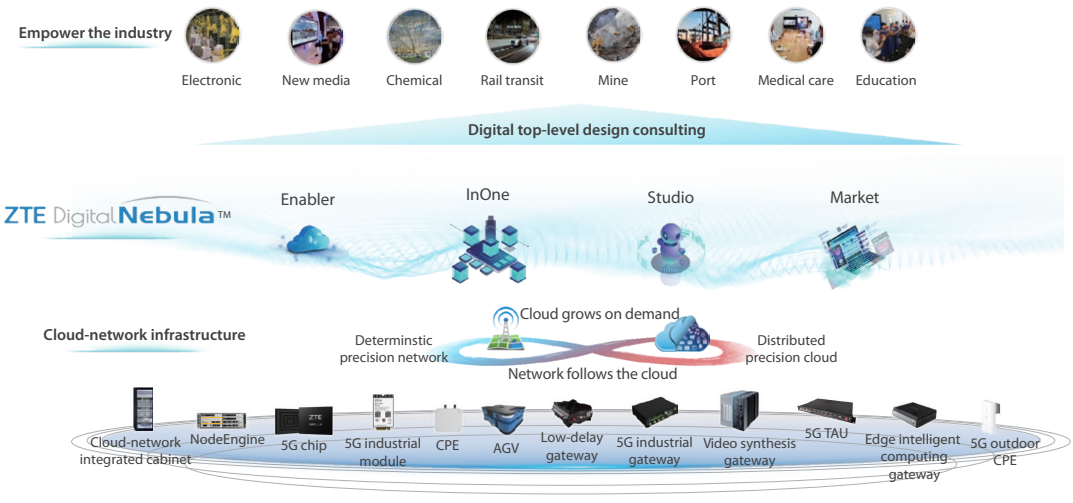


Fig. 1. ZTE's Digital Nebula solution.

better and more economical.

"More" refers to the extensive capabilities and partnerships of Digital Nebula. The Digital Nebula Enabler provides comprehensive ICT technology, and InOne supports the access of thousands of industrial terminals. With an ecosystem of more than 500 partners, the Digital Nebula can integrate the technical capabilities of all its partners to fully assist customers in their digital transformation.

"Faster" refers to the ability of Digital Nebula Studio to help customers and partners develop applications and realize agile business innovations in a prompt way. Enablers provides out-of-the-box technical components to help developers solve technical problems and shorten the time for launching new technologies.

"Better" refers to Digital Nebula's excellent performance, intelligence and security. In 2021, ZTE was the first to be certified as the "trusted digital service provider" by the Ministry of Industry and Information Technology (MIIT), and in May 2022, it was the first to pass the "assessment of the enterprise intelligent operation service capability" by MIIT. Digital Nebula has also obtained a number of authoritative certifications, and achieved global capabilities that are intelligent, predictable, safe, autonomous and controllable.

"More economic" refers to the ability of Digital Nebula to help enterprises reuse assets and save costs. The Digital Nebula Enabler realizes the sharing of basic capabilities, saving investment in technical development. InOne effectively supports the use of existing and new systems within the enterprise, saving the reconstruction costs. Market enables the sharing of various digital assets such as data and capability components both within and outside the enterprise, leading to cost savings in many aspects.

ZTE's Practices

ZTE has leveraged Digital Nebula to explore hundreds of innovative applications in various industries, such as steel metallurgy, transportation, mining, and digital cities. One of its remarkable achievements is at the Nanjing Binjiang Factory where ZTE has implemented data collection and control of the production line, AI quality detection, intelligent warehousing, and AGV transfer using the 5G network and Digital Nebula. The factory has also achieved intelligent security, energy consumption optimization, convenient passage, safe production in the park, and the digital twin of the whole park, which sets an industry benchmark.

Furthermore, in the industrial sector, ZTE has worked with Gree Electric (Zhengzhou) to build a 5G+MEC smart factory, and supported JA Solar in their photovoltaic manufacturing upgrade. These projects have won many honors such as the WSIS Champion Award, the first prize of the "Bloom Cup" 5G Application Competition hosted by the MIIT, and the Top 10 5G Application Cases of the World 5G Convention.

In the mining industry, ZTE provides an integrated smart mine solution based on Digital Nebula to top mine customers including Yankuang Group Co.,Ltd, China Pingmei Shenma Holding Group Co., Ltd, and Shaanxi Zhongmei New Energy Co., Ltd to improve safety and efficiency in production.

In the field of digital government and smart city, ZTE has provided government customers with safe and efficient digital solutions such as urban digital twins, community intelligence and unified network management based on Digital Nebula.

ZTE also provides consulting services for large enterprises such as CITIC Haizhi and Nanjing Port Group utilizing Digital Nebula and its digital transformation methodology.

Moving forward, ZTE will continue to collaborate with its partners to drive digital transformation and high-quality development across various industries based on the Digital Nebula platform. ZTE TECHNOLOGIES

5G-Based Remote Driving: Facilitating Free Movement of RTGC in Ports

Tang Hong

Wireless ToB Integrated Solution Director, ZTE

A rubber tire gantry crane (RTGC) is an important vertical transport tool for container ports, implementing the turnover of containers in the yards. Currently, the driving of RTGC has evolved from on-site control in a narrow cabin hanging under RTGC to remote control in a spacious central operating room, which greatly improves the working conditions of the drivers (Fig. 1). However, remote driving brings a great challenge to network deployment. The network not only needs to meet the requirements of high-bandwidth and real-time transmission of multiple HD videos, extremely low latency and ultra-high reliability of control commands, but also the requirement for RTGC to move at a rate of 15 km/h.

In addition, unlike a rail mounted gantry crane (RMGC) travelling on a fixed railway, RTGC does not run in a full straight line, and more importantly, RTGC needs to be transferred between different container areas and yards, so the wired connection based on fiber can't be adopted.

At present, a typical solution in the industry is to use the WiFi network based on a waveguide, that is, the WiFi signal is transmitted along the tube of waveguide fastened to the ground, and the WiFi signal leaks out through the gaps of the tube. This method avoids direct connection of cables, however, due to the weak leakage signal, RTGC must travel along and close to the tube, which limits its range of movement. In addition, the WiFi waveguide solution still has the following problems. First, the transmission distance of a waveguide is normally less than 50 meters, and during travelling, RTGC needs to switch between different waveguides, which may cause interruption of signal transmission. Second, when the signals of several RTGCs are transmitted in the same waveguide, the service quality may be degraded because of the conflict mechanism of WiFi channels. Third, when a RTGC needs to be transferred between different container areas and yards, the tube of waveguide cannot cross a road, and in this case, remote driving cannot be implemented.

For its large uplink bandwidth, low latency, high reliability, network slice isolation, and precise SLA guarantee, 5G has attracted the attention of port owners and

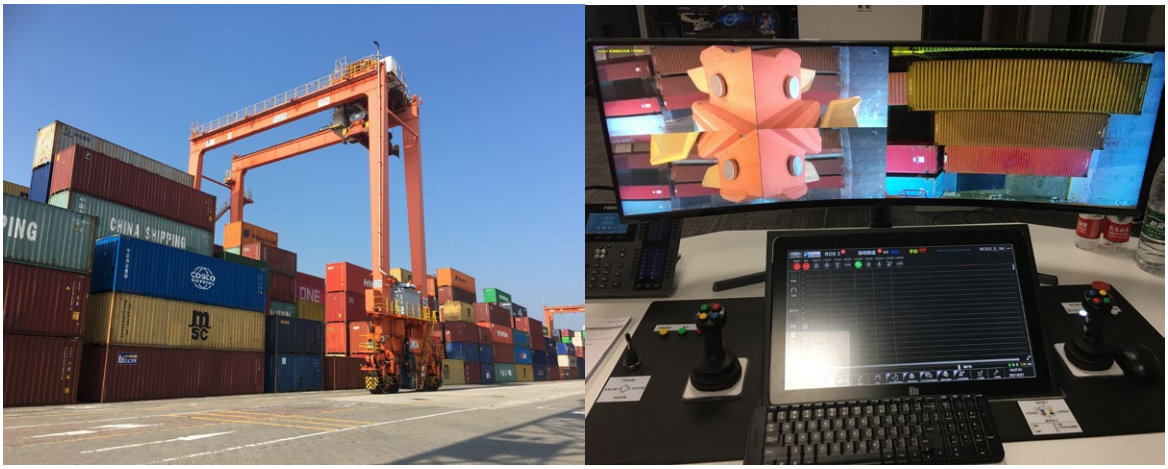


Fig. 1. Remote driving scenario of RTGC.

has been widely adopted in port scenarios. However, for the remote driving of RTGC in the port, the 5G network still faces the following challenges: the large uplink bandwidth caused by the backhaul of multiple HD videos, the low network latency and high reliability required by the two-way transmitting and receiving of control commands, and the concurrent services caused by the remote control of multiple RTGCs at the same time. ZTE's port-oriented 5G remote driving solution now is at the forefront of the industry and has overcome the above difficulties by introducing key technologies and solutions such as SuperMIMO, SuperCell, I-frame collision elimination, frame replication and elimination for reliability (FRER), and local traffic offload function (TOF) based on NodeEngine, a base station with embedded computing engine.

The real-time backhaul of HD videos of RTGC remote control requires a network with large uplink bandwidth capability. Generally, there are two to four RTGCs deployed in a 400-meter container area, and each RTGC has four to six HD video cameras for video backhaul. Therefore, there are totally 24-channel HD videos at the same time. Considering the probability of I-frame collision, the maximum uplink instantaneous rate can reach over 250 Mbps. Taking the bandwidth of 100M in the 3.5G band of ITU as an example, an uplink bandwidth of 180–200 Mbps can be provided in practical applications, which cannot fully meet the transmission requirement. ZTE's SuperMIMO can eliminate cell boundaries through the multiple-input multiple-output antenna technology and improve spectrum resource utilization through the space division multiplexing technology. The maximum cell capacity can be increased by four times, effectively meeting the requirement for large uplink bandwidth for HD video backhaul of RTGC.

The transmission of remote control commands for RTGC requires a network with very low latency and very high reliability.

Generally, the bidirectional transmission delay of control commands is required to be less than 20 ms, and the reliability is required to be above 99.99%. This is a challenge for conventional 5G coverage. Especially when a RTGC travels at the edge of a cell or frequently switches between multiple cells, the signal quality may be degraded, which may increase the transmission time and retransmission times of control commands significantly, and the quality of service may be affected in a severe case. The SuperCell technology provided by ZTE can eliminate inter-cell interference, expand cell coverage, reduce cell handover times, and greatly meet the low latency and high reliability requirements of control commands by combining multiple adjacent cells into a logical cell.

Moreover, ZTE's unique NodeEngine, self-developed function software, and industrial grade edge gateway can enhance the 5G capability for RTGC remote driving. For example, the I frame collision cancellation technology is used for video optimization. By optimizing video encoding and decoding algorithms on the edge gateway, the periodic I-frame design can be cancelled. Alternatively, an AI application can be deployed on NodeEngine to identify the cameras with I-frame collisions and provide suggestions on adjusting the I-frame period, so as to greatly reduce the instantaneous impact of video on network bandwidth. For control commands, the FRER technology is used to realize the function of dual-transmission and optimal-receiving, which means that the same signal is sent to NodeEngine through two different frequencies on the edge gateway, and the FRER software selects the optimal receiving signal. This greatly reduces the risk of dependence on the signal quality from a single frequency. At the same time, the FRER function based on different frequencies also avoids the problem of simultaneous cell handover on different frequencies in the overlapped coverage area, and solves the pain points of RTGC remote driving when crossing a road between different container areas in the yard. In addition, the local traffic offload function of NodeEngine can quickly offload RTGC remote driving traffic from the base station side to the local campus, avoiding the traffic passing through the core network UPF, thereby reducing the network latency to less than 10 ms. The local traffic offload function of NodeEngine and the traffic offload function of the core network UPF can inter-backup to increase the robustness of the network.

ZTE's 5G-based remote driving solution is being trialed and verified in some ports in China. This technology can be used not only for remote driving of RTGC, but also for remote driving of RMGC, quayside container crane (QC) and intelligent guided vehicle (IGV) in the ports. In addition, as a universal remote control technology, the 5G-based remote driving solution can also be widely used for remote control of electric traveling crane in steel and metallurgy, as well as remote driving of unmanned mining trunk in mines. This solution has a wide application prospect. ZTE TECHNOLOGIES

5G Private Network Solution for Open-Pit Mines: Promoting Large-Scale Application of Unmanned Mining Trucks

Zhou Jianhua

ToB Architect of ZTE RAN Product Planning

Open-pit mines include open-pit coal mines and hillside stone mines. In an open-pit coal mine, the surface soil is stripped off to form a huge mine with a depth of ten to hundreds of meters. The coal seams buried at the bottom of the pit are dug up and transported to the coal storage area. In a hillside stone mine, stone materials are excavated from top to bottom and transported to the unloading area at the foot of the hill. In recent years, the open-pit mining industry has proposed an intelligent development goal of "safety, fewer people and unmanned coal mining", and there is an urgent need to reduce costs and increase efficiency. With mature applications of new technologies such as machine vision, self-driving, remote control and 5G wireless communication, open-pit mining is rapidly evolving to intelligence. As the connection infrastructure of intelligent mobile equipment, the 5G private network has been widely used in the core production domain of mines.

Intelligent Open-pit Mining Creates Need for Wireless Communications

Open-pit coal mining involves explosion, loading, and transportation. In the process of intelligent transformation, new services are introduced such as unmanned mining truck transportation, remote control of electric shovel, auxiliary equipment monitoring, and intelligent vehicle management and control. Wired optical cables cannot meet the mobility requirements of mining trucks, which has created the need for 5G wireless networks.

An open-pit mine covers a wide area, ranging from two square kilometers to dozens of square kilometers. The core working surface is slowly advanced, gradually getting away from the coverage area of base stations. Therefore, it is necessary to swap and redeploy some base stations. There are dozens to hundreds of unmanned mining trucks, electric shovels, excavators, earth-moving trucks, and other heavy equipment in the open-pit mine, which imposes high requirements on the uplink capacity of the network and the low latency and high reliability of remote control instruction transmission.

Open-pit mines have high requirements for production safety and reliability. When there are tasks for high productivity, 24-hour production is required and network failures will greatly affect mining

efficiency and operation benefits.

5G Networking and Coverage Solution for Open-Pit Mines

Generally, in small-and-medium-sized open-pit mines, a hybrid 5G private network is used to construct an independent UPF resource pool in the mining area for disaster recovery and ensuring that production data does not go out of the mines. The public network and private network share 5G new radios (NRs), and traffic is logically isolated through the slicing technology. Physical resource blocks (PRBs) are deployed to reserve high-priority air interface resources for private network services. In a large open-pit mine, security requirements are extremely high. In general, an independent private network solution is deployed to provide the highest security, in which base stations and the core network are exclusively used and physically isolated from the public network.

Considering the distinct environments and requirements of each functional area, the planning of the open-pit mine network needs to be tailored to individual areas. In a mine or a large-scale operation platform where overlapping coverage and co-channel interference are serious, SuperCell is needed to avoid frequent handover and co-channel interference. On the transportation road, line coverage is needed to reduce cell handover and ensure service experience of continuous driving. In living areas and coal washing areas, full coverage is needed to make a large number of terminals connected.

For the scenario where the working surface of an open-pit mine moves slowly, ZTE has developed trailer-type movable base stations that integrate the antenna, baseband and mast. The antenna can move upwards and downwards, as high as 18 meters, and has strong wind resistance capability. The movable base stations are flexible and can quickly complete swap and network recovery.

5G Enhanced Technologies Ensure Continuous High-Intensity Operations of Core Production

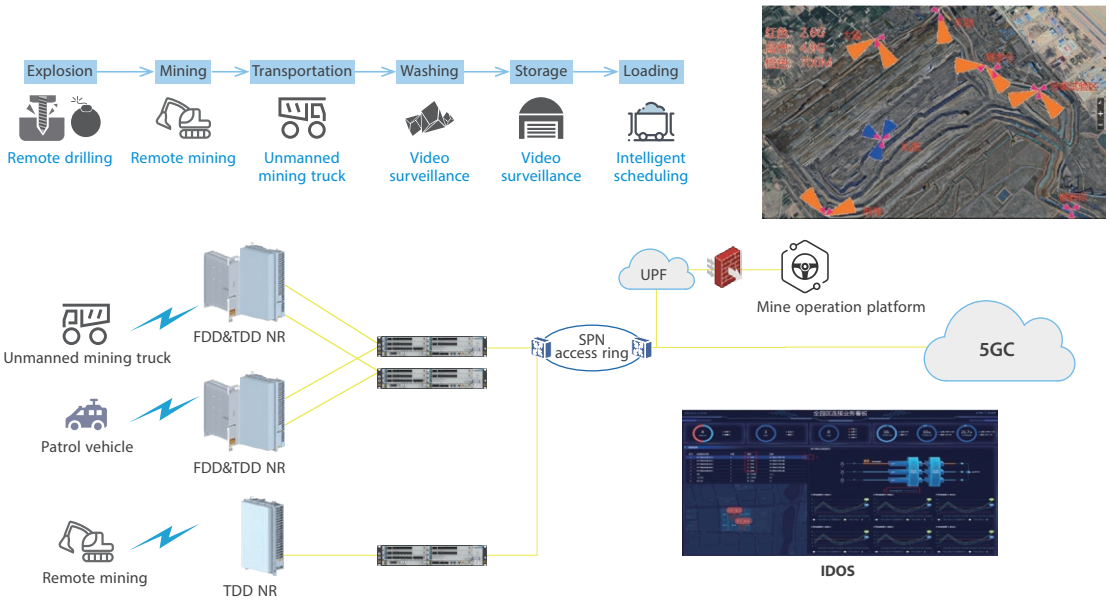


Fig. 1. 5G networking and coverage solution for open-pit mines.

Business in Complex Open-Pit Mine Scenarios

The FDD+TDD dual-band network uses different features of FDD and TDD to complement each other in coverage to meet the changing mine environment. When the unmanned mining truck is moving, it can be connected to an appropriate frequency through the inter-frequency interoperability policy to achieve dynamic load balancing. The dual-frequency networking also improves network availability, preventing single-frequency network faults from affecting production business.

For core production business such as unmanned mining trucks and remote electric shovel, frame replication and elimination for reliability (FRER) is used to transmit control instructions. The sender replicates multiple copies of a data frame that needs to be transmitted, generates a sequence number, and then transmits the data frame on a disjoint redundancy network path. At the destination, the copies are checked according to the sequence number of the data frame, and the duplicate ones are discarded. In this way, seamless redundancy transmission is implemented, and low-latency high-reliability guarantee is provided. When the mining truck needs to be taken over remotely due to a fault in self-driving, the video backhaul delay and picture quality can affect the driving experience. ZTE's industry-leading ultra-low latency video transmission technology reduces the end-to-end delay from about 300 ms to less than 80 ms. Its video technologies such as error correction and packet loss prevention can ensure smooth high-definition pictures and improve remote driving experience.

To meet the uplink large capacity requirements of unmanned mining trucks and remote electric shovels in open-pit mines, SuperMIMO is used in SuperCell networking to enhance the uplink capacity. Four distributed 8T8R RRUs are deployed to form a 32T32R multi-antenna system. In the MIMO system, multiple nodes send and receive signals in a unified manner. On the premise of ensuring continuous self-driving of unmanned mining trucks, the uplink capacity can be increased to ensure smooth backhaul of multi-channel videos.

The intelligence digital operational service (IDOS) for open-pit mine scenarios manages 5G terminals, NRs, UPFs, core network, and production businesses, and presents end to end the status and performance indicators of each node of service flow links. By setting guarantee requirements, quality monitoring, and problem identification, demarcation and location, a closed-loop SLA guarantee is built to make the 5G private network better serve production operations of the open-pit mine.

5G Private Network Continues to Empower Intelligent Transformation of Open-Pit Mines

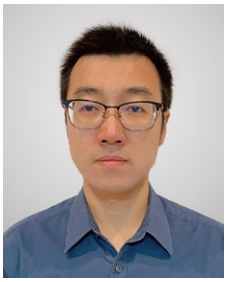
ZTE has assisted China's operators in deploying 5G private network solutions in several open-pit mines in Xinjiang, Inner Mongolia, Shaanxi, and Anhui, which have passed commercial acceptance. In some projects, the mining trucks allow security personnel to get off the trucks, truly achieving unmanned operations—self-driving. With the growth of open-pit mining businesses such as unmanned mining trucks and remote electric shovels, 5G private network will continue to enhance the intelligence of open-pit mines. ZTE TECHNOLOGIES

WISCO: Building an Industry Benchmark for 5G Fully-Connected Factories

Wuhan Iron and Steel (Group) Corporation was the first super-large iron and steel complex established after the founding of the People's Republic of China in 1949. In 2016, it merged with Baosteel Group Corporation Limited to form the China Baowu Steel Group Corporation Limited, which is now the country's most modern and competitive iron and steel joint enterprise and the world's leading modern steel conglomerate.

Since 2021, Wuhan Unicom, ZTE, and Wuhan Iron and Steel Company Limited (known as WISCO) have worked together to build a 5G full-connected factory, which is the first project to deploy dedicated 5G core network and transport network in the enterprise campus in Hubei Province. Six applications have been deployed based on this 5G private network, including "5G+ intelligent iron and steel control platform" and "unmanned overhead travelling crane".

The iron and steel industry involves various stages such as material selection, ironmaking, steelmaking, continuous casting, rolling steel, energy & environmental management, logistics management, and quality management. However, the IT level of the industry varies widely, and many links still rely on manual operations, resulting in low production efficiency. In response, China Baowu has been promoting industrial intelligence since 2019. Meanwhile, with the arrival of 5G era, China Baowu is focusing on using 5G networks for efficient production, safe production, energy saving, consumption reduction, and high-value equipment guarantee. They also aim to develop more diversified 5G+ industrial Internet applications.



Liu Jia

Wireless Product Planning Director, ZTE

After two years of exploration and practice, WISCO has developed a "1+N+X" 5G construction and application mode.

"1+N+X" Mode

"1" Dedicated Core Network

Traditional ToC core networks cannot meet the diverse requirements of industry users. To address this, a dedicated 5GC has been directly deployed in the WISCO campus to meet their requirements for physical device and data security isolation. This ensures that service data stays within the campus while also providing users with very low service latency and dedicated service SLAs.

"N" 5G Shared Base Stations

Currently, 63 5G base stations (excluding private 5G network sites) have been built in the WISCO campus, with the 5G coverage rate reaching over 95%. This is one of the largest 5G campus networks in China. These 5G base stations can meet the network requirements of ToC users through network sharing, and the service requirements of ToB users through network slicing. At present, the outdoor 5G campus network can carry non-production services such as environment monitoring, device status monitoring, and HD video backhaul with the daily average data traffic reaching 4 TB.

"X" Industrial Control Private Networks

Compared with ToC networks, ToB networks have stricter requirements for network capabilities such as delay and reliability in their industry application scenarios. Providing highly cost-effective network connections has become one of the core capabilities of ToB networks.

In the 5G network construction of WISCO, industrial control private networks are built in different factories according to their specific service scenarios in the production domain. The ZTE 5G computing power base for industrial control provides an integrated solution that includes terminals, edges, clouds, networks, and services. It also provides end-to-end service connection monitoring. The typical capabilities of each part of the 5G computing power base for industrial control are as follows:

- SE9102 is an industrial control gateway, which is an important component of the "terminals" and "edges". In the project of WISCO, it is connected to both PLC and HD IP cameras, and offers key network capabilities such as highly reliable transmission of control data and low-latency video backhaul. Industrial-grade product design with a protection level of IP66 can meet the requirements of various harsh environments.
- The dual-band 5G network (2.1 GHz+ 3.5 GHz) ensures the security and reliability of the network to the highest degree through independent physical devices. On-site engineers can simulate more than 10 types of network faults to ensure that single-point radio link faults do not affect services. Even if the 5G base station backhaul link is interrupted, the existing services on site can still be kept for more than 24 hours.
- The SE9102 and the NodeEngine base station with a built-in computing engine can collaborate to create an inter-frequency dual-transmit optimal reception channel with a network latency of 20 ms@99.99%. In addition, service

data can be offloaded and processed locally in the shopfloor through the NodeEngine base station with a built-in computing engine, achieving the integration of "network" and “service”.

- The IDOS R88 is an intelligent digital O&M portal for enterprise users. It is a lightweight, plug-and-play, end-to-end, intelligent, and minimalistic O&M system that provides end-to-end visual monitoring of service scenarios, including the performance data of the entire network, system fault alarms and SLA assurance. The IDOS R88 works with the NodeEngine base station with a built-in computing engine to realize the integration of cloud and network within the private network of WISCO. This enables fast deployment without the need for additional hardware.

5G Brings Infinite Possibilities

In November 2022, China's 5G+ Industrial Internet Conference was held in Wuhan, Hubei Province. The conference was jointly hosted by the Ministry of Industry and Information Technology and the Hubei Provincial Government with the theme of "Integrating Everything with Digital Intelligence to Create the Future". It showcased the latest achievements of China's integrated development of the 5G+ industrial Internet. The "unmanned application of WISCO based on 5G industrial control private network" jointly built by ZTE and Wuhan Unicom with WISCO was selected as a typical application example at the conference.

ZTE’s 5G computing power base for industrial control promotes the integration of IT, CT and OT while meeting the high reliability requirements of industrial control. It has achieved the large-scale implementation of the unmanned overhead travelling crane in hot-rolling, cold-rolling, and silicon steel production shopfloors. The on-board PLC is connected to the warehouse management system through 5G, and the HD videos from inside the factory are transmitted back to the centralized control room in real time, enabling unmanned and automatic control of the overhead travelling crane. This has greatly improved the safety and overall efficiency of production. In the future, ZTE’s 5G computing power base for industrial control will also be applied in more core production fields such as smart molten steel transport and unmanned stacker-reclaimers.

WISCO Model Leads Intelligent Digital Transformation of Steel Industry

Under the guidance of 5G full-connected factory construction, WISCO, a leading enterprise in the steel industry in China, is continuously strengthening the penetration of 5G technologies in the core production field. They are moving from single-point scenarios to systematic and comprehensive applications in production lines, shopfloors, campuses, and enterprises.

ZTE will collaborate with Wuhan Unicom to further improve the end-edge-cloud-network integration capability of the 5G computing power base for industrial control. They will explore more core production scenarios of WISCO and build an industry benchmark for 5G fully-connected factory. The model of WISCO will also be applied to more steel companies, facilitating the intelligent digital transformation of the steel metallurgy industry and promoting the industry’s long-term high-quality development. ZTE TECHNOLOGIES

To enable connectivity and trust everywhere