ZTE

ZTE Industry 5G Core
White Paper

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1 Industry Insights & Trends

5G ecosystem gradually becomes mature and extends to the vertical industries.

In the first quarter of 2021, the number of 5G terminal connections reached 285 million in China, and nearly 819,000 5G base stations were built accumulatively, achieving continuous coverage in key areas. China's 5G terminal connections accounted for over 85% of the world. By April 2021, 162 operators in 68 countries/regions around the world had launched 5G commercial services that comply with 3GPP standards.

As the commercial use of 5G networks accelerates, 5G ToB applications have entered the import phase, and 5G applications are gradually expanding from the peripheral links to the core fields of the industry. The following applications will be launched first, such as 4K/8K UHD live broadcast, intelligent recognition, HD video monitoring, machine-based visual quality detection and remote consultation. The applications that are common in industries will enter the local replication phase, such as AGV, smart mine and smart port. Immersive applications with cloud-edge collaboration, and low-latency high-reliability remote control applications have entered the exploration phase, and will be mature gradually.

Early Application	Gradual Replication	Technology Exploration
• 4K/8K Live broadcast • HD video monitoring • Machine vision based quality detection…	• Smart mine • Smart harbor • AGV • ……	• Immersive cloud-edge collaborative application • Low latency, high reliable remote control

5G Industry Application Development Trends

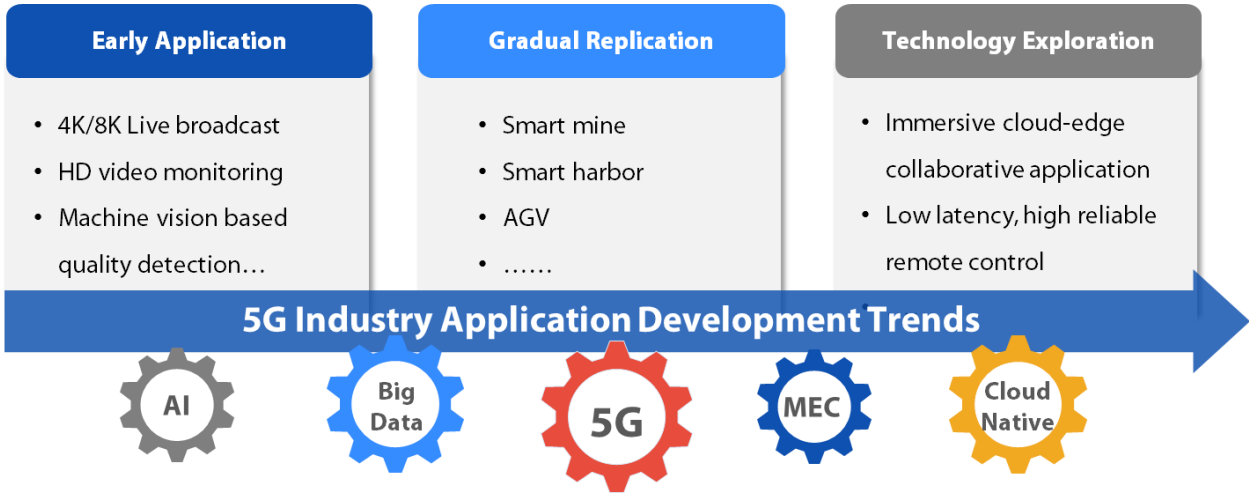AI Big Data 5G MEC Cloud Native

Figure 1-1   5G Industry Application Development Trends

To better promote the expansion of 5G into vertical industries, the 3GPP R16 standard has enhanced to multiple features to support TSN, to meet the requirements of industrial Internet, industrial control automation, grid power distribution automation and other scenarios. uRLLC is enhanced to make the network SLA visible and further improve reliability. Similarly, ETSI has released the collaborative architecture of MEC and 3GPP specifications to support the development of the edge computing ecosystem. In the future, 3GPP will continue to optimize and improve networks in accordance with industry

application requirements.

Develop the ToB blue sea and achieve the maximum value of 5G.

As the ToC market growth slows down, the operators' revenue is going to touch the ceiling. According to the investigation of GSMA, 69% of operators think that the ToB market is very important for 5G profitability. Operators generally hope to cross the border and build a new ecosystem with industry customers and players in other fields to explore the potential value of 5G in the future. In recent years, as the digital transformation of the industry goes towards in-depth development, the requirement for industry private networks is growing. As a key infrastructure for various innovative applications, private 5G network has become a rigid demand for digital transformation.

According to the report released by GSMA Intelligence, enterprise-level applications will account for 54% of the whole cellular connections by 2025. During 2023~2025, 25% - 40% of small/medium-sized enterprises will use the services provided by private network.

The industry private network market is continuously growing. The consulting firm Grand View Research predicts that the global private 5G network market will reach US $919.7 million in 2020, and the CAGR in 2020 - 2027 will reach 37.8%. The private 5G network market will continue to grow with the customer demand of vertical industries.

Industry 5G private network leverages various industries.

As the vertical industry has multiple realms, the ToB market presents fragmented requirements. Industries such as industrial manufacturing, power, security protection and finance have different requirements for network coverage, reliability, security isolation, data confidentiality, equipment mobility and network control. How can 5G leverage the vertical industry? How to meet individualized requirements of enterprises? It is a subject that is being explored in the industry.

At present, China's major operators have released private network solutions. Although the names are different, the architecture is the same. They can be summarized as virtual private network, hybrid private network, and independent private network, all of which can flexibly meet the needs of industry customers for security isolation, service quality assurance, and business services.

In the future, private 5G network will be introduced in various industries to fully integrate AI, cloud computing, big data, and MEC technologies by taking advantage of 5G network capabilities with large bandwidth, low latency, high reliability, and multi-connectivity to achieve digital transformation and improve production efficiency.

2 Analysis & Recommendations

2.1 Major Applications and Requirements

ToB industry applications include smart city, smart campus, smart healthcare, smart logistics, government & financing, industrial manufacturing, smart grid, V2X applications, and tactile interaction. They cover all aspects of human social activities.

Service Category	Service Requirements
Video surveillance and security protection	It is used for security preventive inspections in the campus/factory area, remote video surveillance of production lines, machine vision, remote operation/maintenance and training based on AR/VR, campus management and intelligent service operation. It has high requirements for uplink/downlink bandwidth of data and network.
Collection & detection	There are many network terminals, which are used for environment detection, service data collection, and real-time edge data analysis. This type of services require low data latency and large bandwidth transmission.
Industry control	The secure, reliable, and efficient operation of industrial production requires strict network isolation, high reliability, and deterministic latency.
Terminal mobility	Robots, AGV, driverless vehicles, drone, and other online mobile terminals require high network latency, coverage, switchover, and precise positioning.
Group communication	The dispatch and multimedia push for industrial operations require group calls, broadcast, and priority control.

Figure 2-1 Analysis of Industrial Application Requirements

To match the features of industrial applications, the network oriented to ToB industry applications needs to support diversified communication service capabilities, including large bandwidth (such as video and AR/VR), ultra-low latency (such as autonomous driving and industrial manufacturing control), ultra-high reliability (such as autonomous driving and control). Wide area network coverage (such as beyond-visual-range drone and ATG), and deterministic network services (such as remote control and smart health care), diversified and flexible service deployment capabilities, and on-site access, edge, and centralized deployment. Industry private networks also need to provide secure and reliable communication equipment and complete security assurance mechanisms, including but not limited to authentication, access control, data confidentiality, and data integrity.

The requirements of industrial applications for diversified and differentiated network services are different from those of traditional ToC network technologies. They are summarized as three core points:

Converged access

Industrial applications need more extensive access, such as smart logistics. 5G connection is a basic request,

so is NB. For industrial manufacturing, 5G + optical network mode is the most effective communication solution. As a low-cost solution, WiFi6 will become an extension of indoor coverage. In addition, different applications also have differentiated requirements for specific 5G connection capabilities. For example, monitoring in a smart city has a strong demand for large uplink bandwidth, while tactile interaction needs balanced uplink and downlink. Industrial manufacturing has a strong demand for time determinacy in addition to large uplink bandwidth.

Determinism

Determinism refers to the deterministic bandwidth, rate, jitter and latency required in service development. Determinism will be a key indicator of ToB network, and the determinism guarantee rate will become the key criterion of the availability of ToB network. For example, a network whose uplink bandwidth is about 50Mbps and whose end-to-end latency is around 25ms cannot meet the requirement that the latency of the power distribution network should be less than 20ms. In this case, it is an unavailable network according to the rigid requirement of power distribution network, but for a smart city, it is a highly available high-quality network.

Around Determinism, 3GPP has made numerous improvements at the wireless and network sides to improve the determinacy of 5G network, such as wireless mini slot and pre-scheduling. The network side has also pushed the ToC-oriented BE (best effort) network transforming into the ToB-oriented Deterministic network, including but not limited to slicing, PNI-NPN, CUPS and ULCL traffic offloading, to cooperate with the UPF deployed on the edge. Cloud-network integration is the first to be implemented on the edge, and services are deployed locally. In some industries with high requirements, private networks are directly established to achieve determinacy.

Ubiquitous edge

Ubiquitous edge refers to industry-oriented edge cloud-network coexistence. The network deployment at edge includes such scenarios as private 5G network, UPF local deployment and base station traffic offloading. Edge cloud is committed to edge heterogeneous enhancement and the collaboration between cloud and network at the edge. Ubiquitous edge has become the key feature of ToB network, even in the virtual private network based on operator networks, the UPF and computing will also be deployed downward to the edge. At the same time, ubiquitous edge provides industry customers with better security solutions, maximizing the security to prevent production data leaking out of the campus or meeting the requirements of industry regulations.

2.2 Industry-oriented Network Construction Solution

The construction of ToB network needs to fully consider the service requirements. Meanwhile, by considering the characteristics of each industry, it needs to combine the factors such as cost, network maintenance, security and reliability. The ToB network will be constructed in three modes:

➔ Like ToC, it is constructed by the operator. The operator builds a shared ToB public network to serve the industry through slicing and big edge solutions.

➔ The network is jointly constructed by the operator and the enterprise, and some network equipment is exclusively occupied or owned by the enterprise. This mode can ensure that the network service quality is guaranteed for the industry and the application data will not leak out of the campus.

➔ To meet the requirements of business development or industry regulations, some large-scale enterprises will lead the construction of industry private networks (the private network will be built independently by an enterprise or by an operator).

In the current stage, due to policy and technical restrictions, the construction of ToB network in China mainly depends on the operator. From the perspective of meeting requirements and sharing network resources, the operator provides three industry private network solutions for ToB applications:
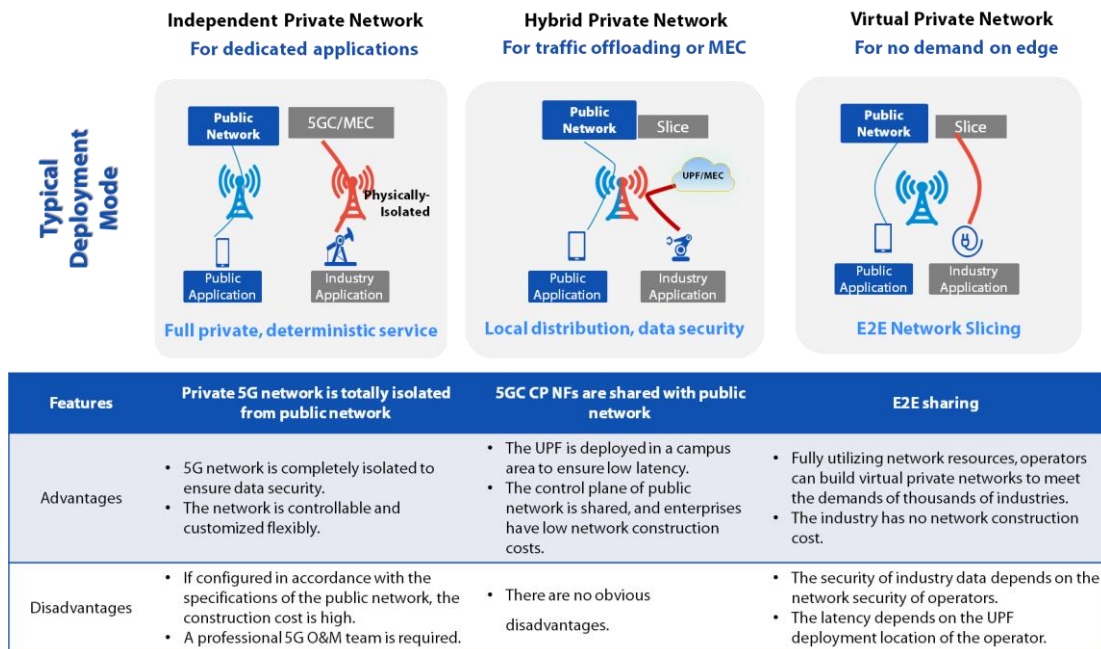

Features	Private 5G network is totally isolated from public network	5GC CP NFs are shared with public network	E2E sharing
Advantages	• 5G network is completely isolated to ensure data security. • The network is controllable and customized flexibly.	• The UPF is deployed in a campus area to ensure low latency. • The control plane of public network is shared, and enterprises have low network construction costs.	• Fully utilizing network resources, operators can build virtual private networks to meet the demands of thousands of industries. • The industry has no network construction cost.
Disadvantages	• If configured in accordance with the specifications of the public network, the construction cost is high. • A professional 5G O&M team is required.	• There are no obvious disadvantages.	• The security of industry data depends on the network security of operators. • The latency depends on the UPF deployment location of the operator.

Figure 2-2   Comparison and Analysis of Private 5G Network Deployment Modes

Virtual private network

The unified ToB network is built, and the slicing technology is used to provide a private network for the industry. Such a shared network can be called a virtual private network. This network solution maximizes the sharing of network resources, including RAN, transmission and core network, to meet the service evolution requirements through the planned network construction by the operator and the dedicated network O&M support from the operator. The biggest disadvantage of this solution is that it cannot provide specific industries with specific and deterministic network services. In addition, it is also impossible to adjust network services in real time in accordance with the industry development requirements. Due to low isolation, uncertainty is brought to industry applications.

Hybrid private network

Due to the weak points of virtual private networks, an exclusive UPF is built for the industry based on the service requirements. This type of network is called a virtual hybrid private network, which has the cost and maintenance advantages of the virtual private network. In addition, because UPFs are dedicated to the industry, an isolation solution that is not available in virtual private network can be provided for the industry, meeting the high data security requirements of some industries. In addition, edge computing can be deployed together with the UPF to effectively reduce latency and improve the service experience of industry customers. This solution has been accepted by many industry customers, and becomes a key solution for 5G to expand into the industry.

Independent private network

An operator builds an independent private network for an enterprise. Because industry customers cannot obtain frequency spectrum resources at present. At the core network level, this construction mode is equivalent to the construction of private networks by enterprises. By building a matching network in accordance with the characteristics of the industry, the independent private network is more specific to industry applications and can better meet the requirements of industry development. It can provide highly deterministic network service guarantee for the industry. Compared with a shared network, an independent private network has a disadvantage with respect to costs. However, because the private network has clear service target, lower cost can be obtained in some application scenarios by tailoring some unnecessary network functions, for example, in the scenario of campus broadband access, mobility, charging, and other features can be tailored. In addition, the traffic forwarding technology (heterogeneous acceleration) can be used to reduce cost further.

Different network construction modes determine the ultimate network capability: 5G network provides multiple network solutions for ToB industry applications. The industry can select only one type of network

solution or a combined network solution according to its own characteristics. For example, for a cross campus office network, the virtual private network provided by the operator can be used. The network used for industrial production or control can be an independent private network. Due to the deterministic advantages of an independent private network, with the development of 5G into the industrial field, the independent private network will gradually become the core solution of industry network.

2.3 Independent Private Network Empowers Digital Transformation

Compared with operators' public networks, an independent industry private network has the following differentiated highlights:

Differentiated Cost

New industry demands continuously increase communication network costs, including infrastructure, network construction, network maintenance, and network compatibility and scalability. This requires that industry private 5G network supports flexible differentiated costs. The costs are optimized according to the characteristics of the industrial applications. For some industrial applications such as FWA, a lower cost policy can be adopted. For some high value-added applications such as industry control, to obtain better determinacy and availability of the network, the investment in network facilities needs to be increased, but the O&M cost can be properly optimized.

High reliability and security

The private network is no longer affected by the shared public network, so the network technology can be enhanced to achieve higher reliability. For example, the dual sessions defined by uRLLC can provide dual transmission replication for industry control. At the same time, each network node adopts the more reliable hot standby technology to achieve 99.9999% high availability required by industrial production. The independent private network is physically isolated to provide higher security than the public network.

Plug & play, easy O&M

In a traditional telecom network, a large and professional O&M support team is required to ensure normal network operation and continuously optimize the network to meet service development requirements. It is not easy for industry users to develop a professional communication O&M team. This drives that the independent private network should have key features such as easy installation and maintenance, thus reducing the technical threshold of network maintenance for industry customers. Simple and effective O&M tools are provided to meet self-configuration and self-management requirements. Remote hosted interfaces are also supported, and can be managed by a third-party professional organization.

Fast customization of functions and in-depth expansion to industry applications

5G, which becomes the cornerstone of digital society, needs to expand network applications into thousands of industries, and industrial manufacturing will become the key "touchstone." At present, the machine vision, equipment management and O&M, remote control, warehousing and logistics, campus security protection and digital-twin services in the industrial field are growing fast. To become the basic communication in the industrial field, 5G must provide network capabilities to meet the needs of industrial development. For example, in production application, the communication mode of uplink for upload and downlink for control is needed. The uplink requires high bandwidth, the downlink requires deterministic control signal, and the network needs to support TSN. In the application scenario of signal collection, such as vehicle-mounted or airborne communication, which are usually based on Ethernet communication, and have a point-to-multipoint communication mode, the network needs to support 5G-LAN. When there are multiple modes such as WiFi, optical fibre, NB and 4/5G in the campus, the network needs to support ubiquitous access capabilities such as multi-access and FMC.

3 Industry 5G Core Solution – i5GC

Oriented to telcos and industry customers, ZTE launched the i5GC (industry 5GC) product on the basis of ToB industry network solution, which not only meets telcos' professional communication requirements for equipment but also addresses the industry's requirements for network services. The i5GC achieves dedicated private network, physical isolation, ultra-high bandwidth/ultra-low latency and deterministic SLA, fully meeting the service requirements of ToB industry customers. The i5GC is oriented towards differentiated customization requirements of thousands of industries. It is based on the standard 5GC to achieve lightweight and industry-specific enhancement, and provides a "simple" and "professional" 5G industry private network solution.
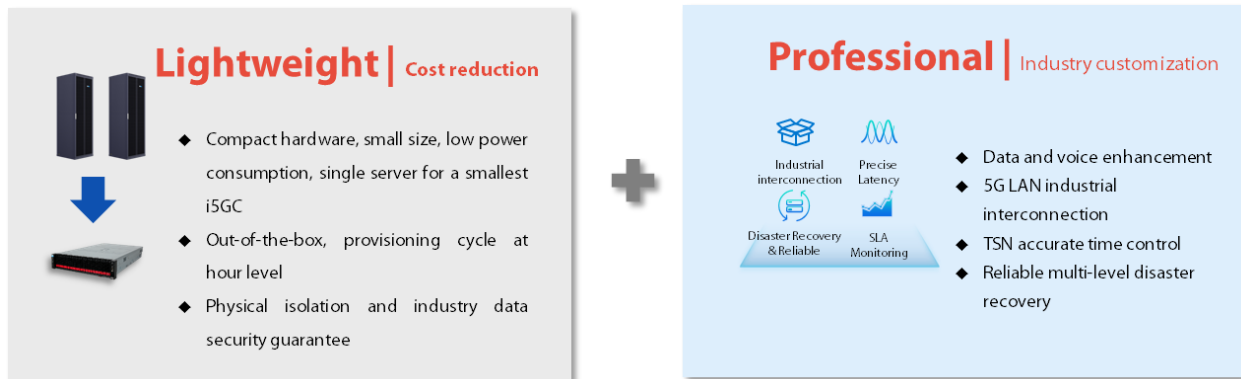
Full-scenario hardware, flexible deployment

The i5GC provides various private network product solution options of different physical forms for different industries in various scenarios. The simplest one is using one server to deploy the lightweight core network to meet the low-cost network construction requirements of the industry. In an industry scenario requiring reliable disaster recovery and high throughput, the standard form is recommended for deployment. For a large campus requiring integrated cloud and network, the cloud-network cabinet is the best choice.

Pocket	Simple	Standard	AIO Cloud-network	Embedded
PC version	1 server	3 servers	Cloud-network cabinet	Embedded BBU or OLT chassis
Emergency relief, family	Medium/small industry 5~10 Gbps	Big/medium industry, highly reliable 10~50Gbps	Medium/big industry Cloud/Network/Application Convergence ~20Gbps	Room space is limited or wireless and fixed are deployed together 5~10 Gbps

Figure 3-1 Full-Scenario Hardware for 5G Private Network

Flexible combination of network functions

The i5GC can be chosen flexibly and tailored. It provides a series of software forms in terms of NF combination, and can be extended and overlapped according to the needs of industry customers.

➡ AMF+SMF+UDM+PCF+UPF: It is applicable to move the whole core network to the edge, providing integrated data and voice access.

➡ AMF+SMF+UDM+UPF: It is applicable to move the whole core network to the edge, providing data access. In order to meet the independent private network with higher reliability and enable continuous services and disaster recovery under the fault scenario, it supports to deploy two levels of UDM. The primary one is the public network UDM and the secondary one is the local UDM.

➡ AMF+SMF+UPF: Reusing the regional UDM, other NFs can be deployed at the edge.

➡ UPF: Only the UPF is deployed at the edge.

In the NF deployment solution, there are the three following scenarios for flexible selection according to the requirements of telcos and industries.
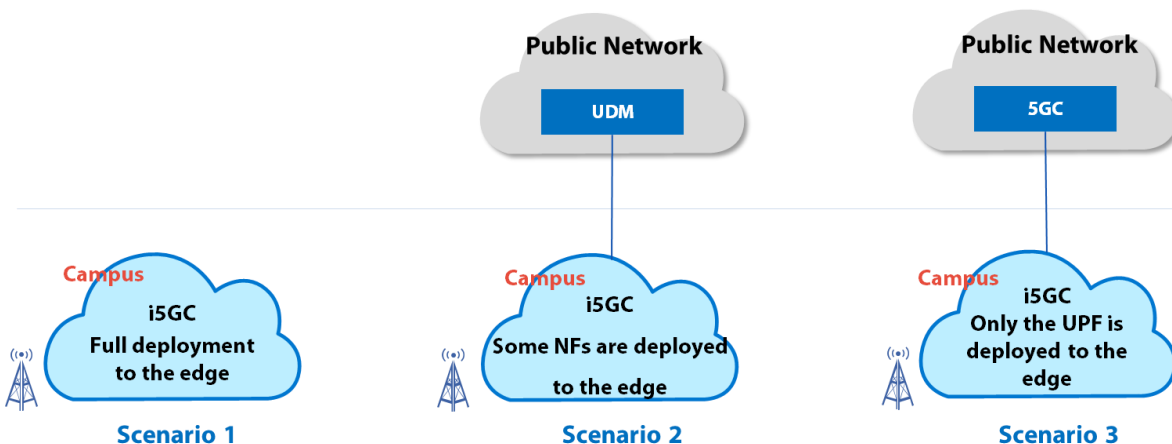
Figure 3-2 i5GC Meets Various ToB Deployment Scenarios

Enhanced connectivity

In order to meet the differentiated requirements of various industries, the i5GC not only provides the basic 5G connectivity, but also enhances the capability over "connection" and precisely empowers the industry.
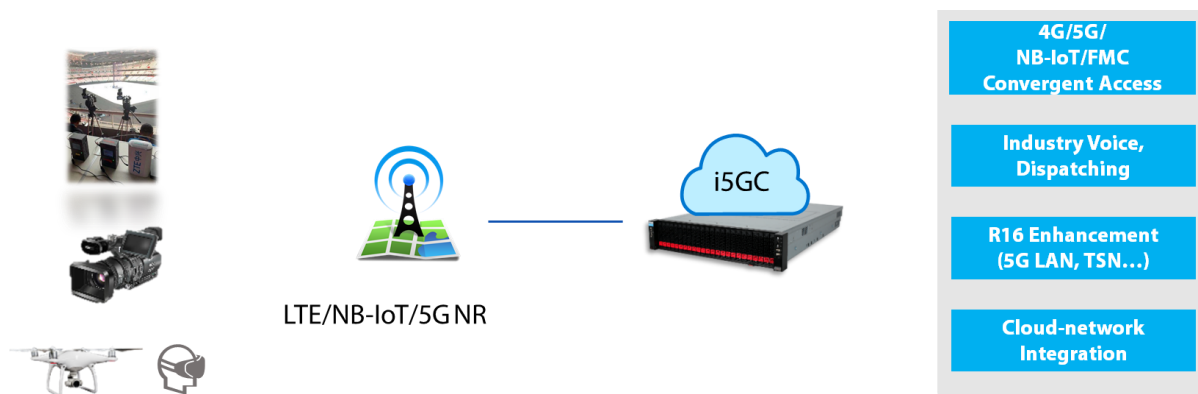

Figure 3-3 Differentiated Connectivity Enhancement for i5GC

Converged access

The i5GC can be expanded to support converged access capabilities such as 4G/5G/eMTC/NB-IoT and future evolution to FMC. The converged simplified core network is deployed to address ubiquitous access of various terminals in the industry campus, implementing unified management and O&M, to reduce the network construction costs and O&M costs for industry customers.

Private network voice enables secure communications security. In order to meet the voice requirements of 5G industry private networks such as enterprise campus and smart mines, i5GC is combined with

lightweight iIMS to provide an overall 5G private network voice solution, providing industry users with voice communication capabilities featuring good experience, low cost, complete functions and convenient deployment. It can be integrated to third-party scheduling system of specific industries to carry out the scheduling function of the voice private network.
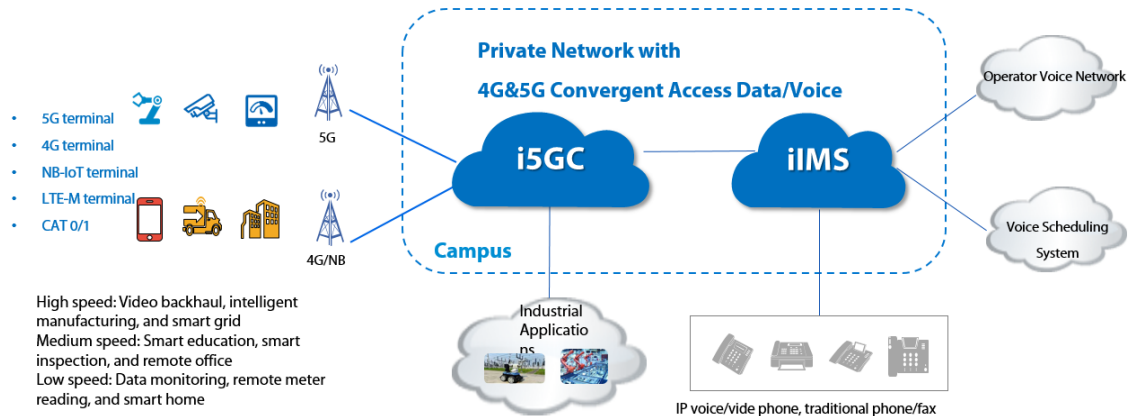

Figure 3-4 Converged Access for Private Network

Industrial enhancement

For intelligent manufacturing, transportation and other industrial fields, the i5GC continuously evolves to 3GPP R16 and supports innovative features such as 5G LAN, QoS Monitoring and TSN, to empower the industry. Through 5G LAN, 5G network can replace traditional wired and L2 networks, providing flexible production environment and improving production efficiency. QoS Monitoring is used to implement end-to-end SLA detection and control, so as to make the industrial network visible, manageable and controllable. By introducing the TSN, the 5GS is connected to the TSN as a bridging device to provide precise forwarding capability and deterministic network capability for the industrial environment with uncertainty.
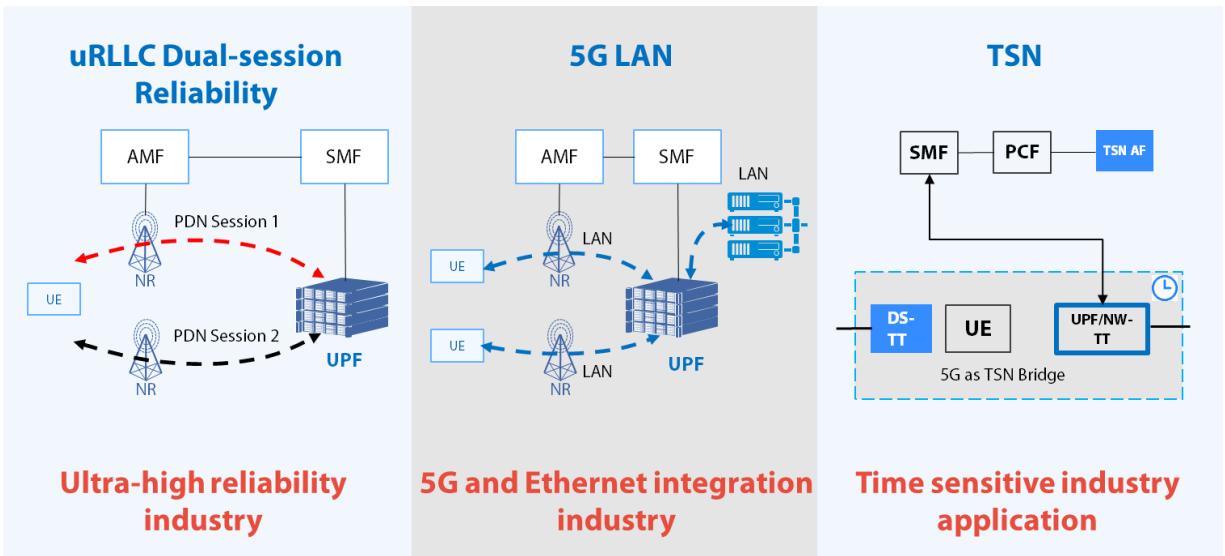
Figure 3-5 Industrial Enhancement

All-in-One (AIO) cloud and network

Based on the i5GC, it supports to continuously expand "network" capabilities and add "cloud" capabilities. With the flexible deployment of dual-core cloud infrastructure and lightweight 5G network, 5G modules, NR, transmission, 5GC, MEC, third-party application and other components are integrated on demand, to build the integrated cloud-network infrastructure with the integrated cloud-network cabinet, empowering full-scenarios of 5G industries.

3.1 Enhanced Connectivity

The i5GC provides enhanced features in industrial fields such as 5G LAN, uRLLC, and TSN. The 5G LAN provides the group communication capability between industrial terminals, so that industrial terminals can quickly set up the working domain and support the unicast / multicast / broadcast communication capability inter industrial terminals. The uRLLC provides ultra-low-latency and ultra-high-reliability communication capabilities, supporting remote control applications. The TSN feature provides deterministic communication capability with predictable, committed and guaranteed transmission latency and jitter, which is one of the most important industrial technologies. In addition to basic features, however, industry applications have stricter requirements for 5G networks. The most critical requirements are as follows:

Deterministic Transmission Capability

The network needs to meet the QoS requirements of key service flows. End-to-end packet transmission can

be guaranteed with millisecond-level low latency and low jitter. It also supports high-precision latency and jitter control, and supports the visualized deterministic flow scheduling mechanism. The precision of a communication network is measured by the packet transmission latency (from the sending end to the receiving end) and transmission jitter (the difference between the latency of a single packet and the average latency). In an industrial environment, the expected transmission latency is low and constant. The smaller the transmission jitter, the better. To meet the harsh requirements of the industrial environment, special implementation must be introduced. The dedicated hardware introduced by the i5GC adopts the PCI NIC form. This NIC supports high-precision clock synchronization, ultra-low-latency forwarding and TSN accurate scheduling and forwarding capability. After the dedicated NIC is applied, the i5GC can support the clock synchronization with nanosecond precision, forwarding delay and forwarding jitter control with microsecond precision. Industry customers need to schedule data streams, monitor data stream status, evaluate data stream scheduling results, and obtain data stream operation reports through the visual scheduling interface. The i5GC provides visual flow status report, and intelligently adjust and optimize the stream according to its status.
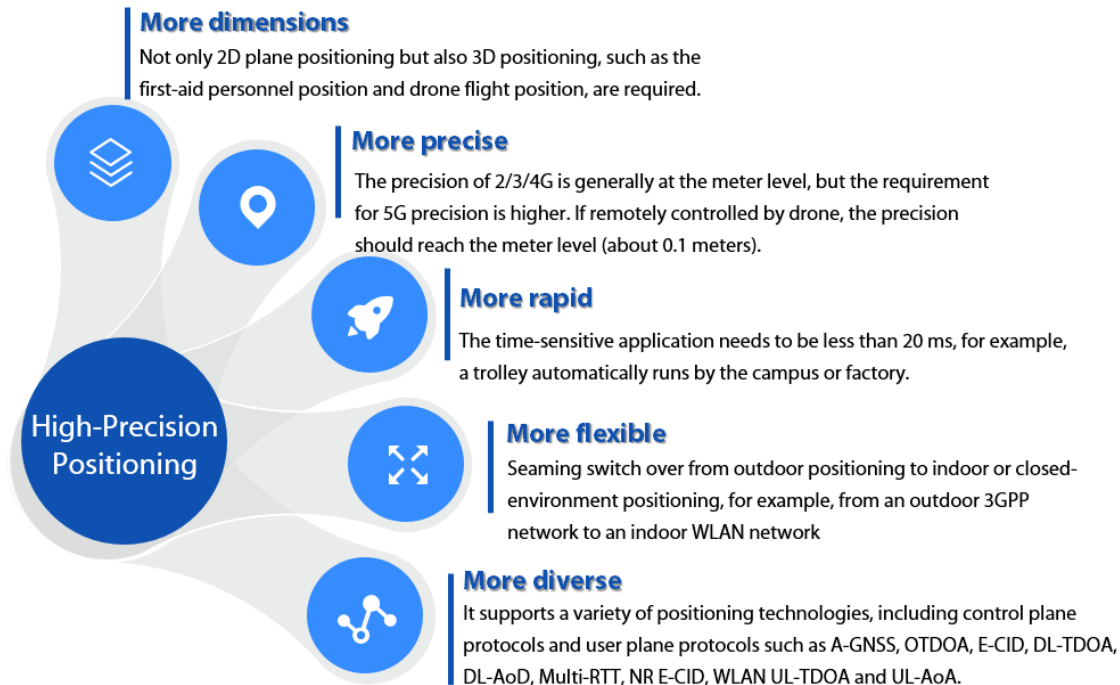
Deterministic service availability

The network needs to provide high-availability equipment, high-reliability transmission channel, full redundancy mechanism, and transmission path redundancy mechanism. The network availability can reach 99.999%. Multiple sets of i5GC are used to deploy fully redundant industrial disaster recovery solutions. It can provide comprehensive disaster recovery for link faults, fire, flood, and other natural disasters. Key data synchronization and disaster recovery are available among multiple sets of i5GC or between the i5GC and the operator's core network. When a fault occurs, the neighbor device immediately generates an alarm, and provides possible fault analysis and processing suggestions. At the same time, with the assistance of the management system, the devices that are operating properly adjust the transmission policy quickly, and key service flows are reallocated among devices to eliminate the impact of faults on services. With the above functions, the i5GC can meet the availability requirements above 99.999% in an industrial environment. On the basis of equipment redundancy, the i5GC provides the parallel redundancy solution of transmission path, such as uRLLC, achieving ultra-high reliable service availability of 99.9999%.

3.2 High-Precision Positioning

Compared with 2/3/4G, the positioning service has higher requirements in the 5G mobile communication network, as shown below.

More dimensions
Not only 2D plane positioning but also 3D positioning, such as the first-aid personnel position and drone flight position, are required.

More precise
The precision of 2/3/4G is generally at the meter level, but the requirement for 5G precision is higher. If remotely controlled by drone, the precision should reach the meter level (about 0.1 meters).

More rapid
The time-sensitive application needs to be less than 20 ms, for example, a trolley automatically runs by the campus or factory.

High-Precision Positioning

More flexible
Seaming switch over from outdoor positioning to indoor or closed-environment positioning, for example, from an outdoor 3GPP network to an indoor WLAN network

More diverse
It supports a variety of positioning technologies, including control plane protocols and user plane protocols such as A-GNSS, OTDOA, E-CID, DL-TDOA, DL-AoD, Multi-RTT, NR E-CID, WLAN UL-TDOA and UL-AoA.

In order to meet the requirements of precise positioning of vertical industry in the 5G era, ZTE i5GC supports to deploy the location management function (LMF) component. The Cloud Native LMF component features flexible and customizable deployment resources and rich positioning technologies. It provides network positioning information through capability exposure interfaces to third-party applications, enriching positioning capabilities.

3.3 Industry Voice

As an important interaction tool, voice is rigidly required in various industries such as finance, education, health care, government affairs, mining, energy, and automobile. In the deployment of 5G industry private networks, voice solutions should be considered at the same time. The voice requirements of industry private networks are quite different from those of ToC networks. For example, the mining sector requires the dispatching console, the airport rail transit requires the dedicated traffic control console, and the railway system requires the V5 access. Therefore, the private network voice solution is considered from the following aspects.

➔ **Mature technologies and good experience:** Due to voice interaction attributes, a mature technical system is a prerequisite for ensuring customer experience.

➔ **Customization capabilities:** Due to the diversity of industrial applications, the best solution for industry voice should hit the core pain points of industries.

To meet the voice requirements of 5G industry private networks, ZTE launched the 5G industry voice solution with i5GC and lightweight iIMS (industry IMS). Following the international standards such as 3GPP and TISPAN, the lightweight iIMS implements IP Centrex and supplementary services, and provides fixed and mobile terminals with the PES/PSS architecture and services. The new 5G voice adopts the higher-definition codec technology and richer call modes, to further improve voice quality and experience. Based on the new 5G voice, ZTE 5G industry voice solution provides the best voice communication capability with better experience, lower cost, complete functions and convenient deployment. The following figure shows the solution architecture.
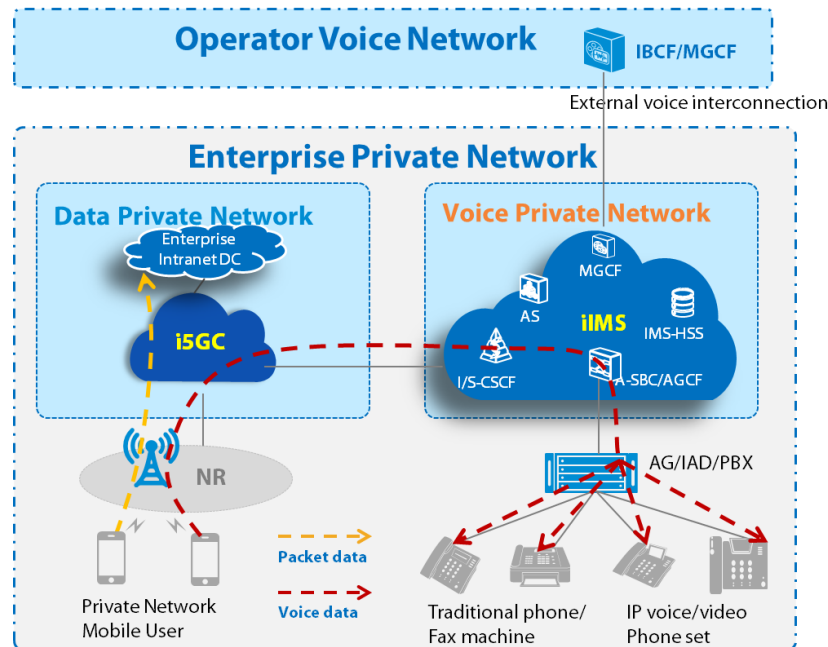

Figure 3-6 ZTE 5G Industry Voice Solution

ZTE 5G industry voice solution has the following advantages:

➔ **Supports multiple types of voice terminals:** Including fixed, VoLTE/VoNR mobile terminal and VoIP terminal.

➔ **Supports voice intercommunication with the operator's public network:** Voice intercommunication between private networks and public networks.

➔ **Supports interworking with the existing scheduling systems of enterprises:** Provides internal scheduling and broadcast functions in the industry private networks.

➔ **Supports auto console:** Supports switching from an auto console to a manual console, and supports the auto console to transferring and playing tones.

➔ **Supports the long and short number function:** Supports dialing short numbers inside an enterprise, and external numbers of an operator can dial the long number to call enterprise terminals.

ZTE has been making long-term efforts in the voice field, and has accumulated rich technologies and case experience. As the 5G private network empowers thousands of industries, industry voice represents the general trend. ZTE will continue to cooperate with operators and industries to innovate and explore 5G industry voice and new 5G voice services, to provide industry customers with high-quality 5G voice services.

3.4 Ultra-High Reliability

Pioneering the 5-level disaster recovery mechanism to fully guarantee the reliable and secure operation of the ToB network
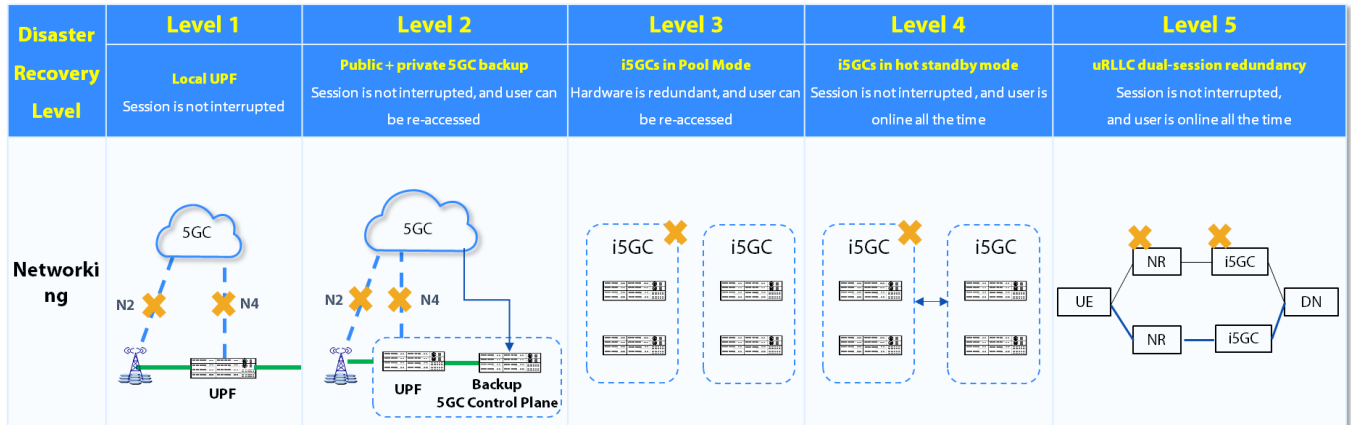

Figure 3-7 5-Level Disaster Recovery Mechanism for ZTE 5G Industry Core Network

Based on the analysis of industry requirements, ZTE provides a 5-level disaster recovery solution to meet the reliability requirements of customers in different industries.

Disaster recovery level 1

When the campus is disconnected from the public network, for example, the transmission line is faulty or the public network control plane NFs are upgraded, the disaster recovery solution ensures that online services are not interrupted in a short period of time.

Disaster recovery level 2

The i5GC can provide high-reliability service assurance for both dedicated private network and dedicated public network scenarios.

In the dedicated private network scenario, the i5GC acts as the active independent private network and a two-level UDM architecture are formed by deploying local UDM and public UDM. The active network includes local NFs such as AMF/SMF/UPF within i5GC and the UDM within the public network. The local UDM is for emergency backup. The operator allocates numbers in the public UDM, and synchronizes the numbers to the backup UDM in the campus. When the link between the campus and the public network fails, services are automatically switched to the local backup UDM. The online services are not interrupted. At the same time, the newly-accessed industrial terminals can still access the i5GC to enjoy 5G services.

In the public network scenario, the control plane of the public network provides access services for terminals preferentially, and the edge control plane provides emergency backup for the public network. When the public network is disconnected or upgraded, mobile terminals reestablish transmission channels through the emergency control plane in the campus to rapidly recover services. After the public network is restored, terminals are automatically switched back to the public network, or are switched back by the user in accordance with the principle of minimum service impact.
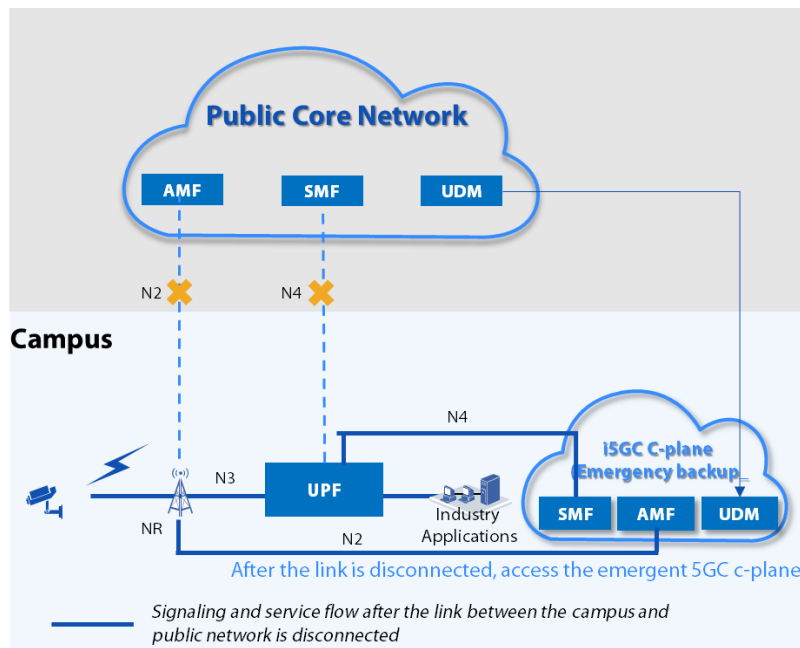

Figure 3-8 Disaster Recovery Mechanism at Level 2

Disaster recovery level 3

Two i5GC systems run in Pool mode for geographical redundancy. It is applicable to most campus private network deployment scenarios, such as video monitoring, smart patrolling inspection, and remote
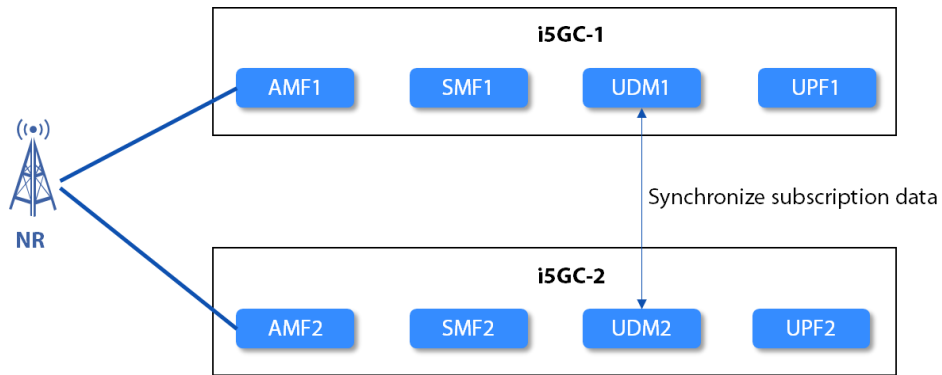
education.

Figure 3-9 Disaster Recovery Mechanism at Level 3

Disaster recovery level 4

Two sets of i5GC are in hot standby mode. Session data is synchronized in real time. When one set of i5GC is faulty, the other set can take over services in real time. The sessions are not interrupted. It is applicable to private network scenarios with high requirements for service continuity, for example, industrial manufacturing.

Disaster recovery level 5

Dual PDU sessions provide redundant transmissions to achieve ultra-high reliability. It is applicable to scenarios with ultra-high requirements for service continuity, such as telemedicine.
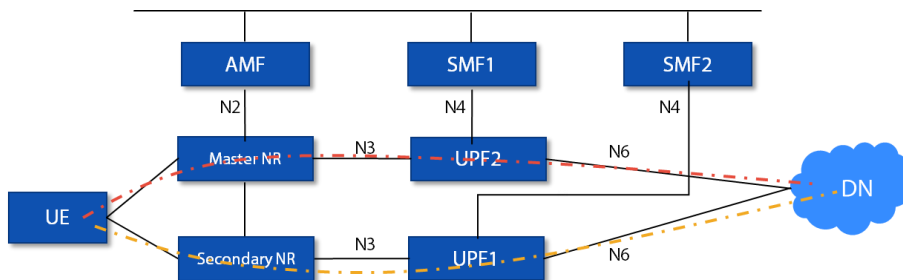

Figure 3-10 Disaster Recovery Mechanism at Level 5

3.5 Ultimate Security

Based on years of 5GC security construction practices in the ToC field, ZTE takes various security measures to build a secure and trustworthy industry private network, meeting the special security requirements of the ToB market, such as trusted access and controllable data.

Enhanced access control, to ensure trusted access to the campus

The built-in confidentiality and integrity protection features of the 5G network are used to prevent the leakage of data information and achieve secure access of terminals. Secondary authentication is deployed to enhance the trusted access authentication of terminals at the industry side.

Multi-level isolation, to guarantee service security

Multi-plane isolation is implemented on the underlying layer to distinguish different traffic. For the differentiated security requirements of different traffic from industry customers, different DNs can be used to isolate services and use secure tunnels to ensure that different types of traffic do not interfere with each other and can be transferred securely.

Cyber resiliency, to make a built-in security system

Taking the cyber resiliency idea, ZTE designs industry private networks based on service continuity, backs up and stores core data locally, and takes over services quickly and locally in case of major security accidents.

Sensitive data protection, to build secure ToB networks

All core services can be moved to the edge, and data flows can be controlled and managed to ensure that data is processed and stored locally in the campus. Privacy protection control is enhanced to ensure normal network O&M and user privacy anonymity, preventing personal information disclosure.

Multi-layer security protection, to implement malicious attack immunity

The physical layer adopts the anti-theft and anti-sabotage design, and strengthens the control of access to the interface and I/O to avoid illegal access to the equipment. The trusted hardware mechanism is introduced to perform layer-by-layer verification to construct a complete trusted chain. The network boundary protection is combined with the host intrusion detection to prevent the horizontal expansion of malicious acts and handle threats timely. The micro segment mechanism is used to realize self-defined traffic control.

Security capability coordination, to achieve co-construction of security services

Based on the concept of security forwarding, it provides security services such as vulnerability fixing and penetration test to the private network, so as to detect and solve security threats timely. With 7*24-hours professional security support, it realizes timely response to major security events and hour-level recovery.

ZTE practices "Integrate security into blood and enhance trust through transparency." The first batch of 5GC products has passed the GSMA Network Equipment Security Assurance Scheme (NESAS) independently audited by the third party security company, and have completed the BSIMM evaluation with high score.

The software security capability reaches the international leading level.

3.6 Openness and Cooperation

From the beginning of i5GC design, ZTE adheres to the concept of openness, and cooperates with mainstream technical manufacturers in various fields such as hardware, NFVI, VNF/CNF and virtualized E2E system integration.

Cross-platform deployment

Based on the concept of cloud native, i5GC uses service-based architecture (SBA), micro-service components, lightweight container, stateless design and other new 5G technologies to build converged core network NFs, thus achieving flexible and agile service innovation, deployment and O&M.

In March 2021, ZTE Common Core, including i5GC, was successfully certified by Red Hat OCP (OpenShift Container Platform). It was the first 2G/3G/4G/5G/Fixed fully converged core network product that has been certified by Red Hat OCP in the industry, and opened a new chapter for the global cooperation between ZTE 5G Core and Red Hat.

OpenUPF

As the link connecting operators and the vertical industries, UPF is the starting point for opening up 5G ToB services. It is deployed most closely to industry customers, and is a pioneer of service development and digital upgrade for the 5G industry. However, the industry UPF is facing challenges such as flexible customization, diversified product specifications, and huge difference in deployment environments. Therefore, ZTE actively works together with operators and industry partners to build an open and unified UPF certification system.

ZTE OpenUPF solution is designed around the product form, service functions, interface openness and unified O&M, so that ZTE UPF and the SMF of different vendors in the authentication system can be integrated quickly to implement plug-and-play, agile onboarding and centralized O&M of the industry UPF.

ZTE actively participates in the research and discussion of the N4 interface decoupling scheme at home and abroad. Based on the current 3GPP specifications, there is still uncertainty about the decoupling scheme of the N4 interface, and there is no feasible unified standard in the industry. ZTE is cautious about opening the N4 interface. Considering the actual integration requirements of industries, ZTE will gradually promote the N4 interface decoupling. So far, ZTE OpenUPF has supported integration with the SMF of other vendors.

4 Industry 5G AIO Cloud-Network Solution – iCube

The digital transformation of industry puts forward new requirements for the rapid integration of connectivity, computing, and applications. A one-stop solution with full integration, on-demand loading, and out-of-the-box delivery is urgently needed to meet the challenges of network connectivity, edge computing, service integration, provisioning, and O&M for constructing private networks for the campus.

ZTE 5G iCube (industry Cube) is an all-in-one (AIO) cloud-network solution for 5G industry, which builds a lightweight 5G network close to the user, and constructs the cloud infrastructure that supports dual-core engine of VM and container, and unified and simplified NM. The solution provides industry customers with connectivity and computing resources featuring on-demand cloud-network synergy. In addition, it supports factory prefabrication and on-site one-click provisioning, greatly reducing the complexity of constructing and maintaining a private network. During the process of launching the exclusive private network of the opera, the solution has made innovative breakthroughs in network construction form, industrial application deployment mode, and end-to-end turnkey delivery of AIO cloud-network.

iCube lays the foundation for digital transformation of the industry
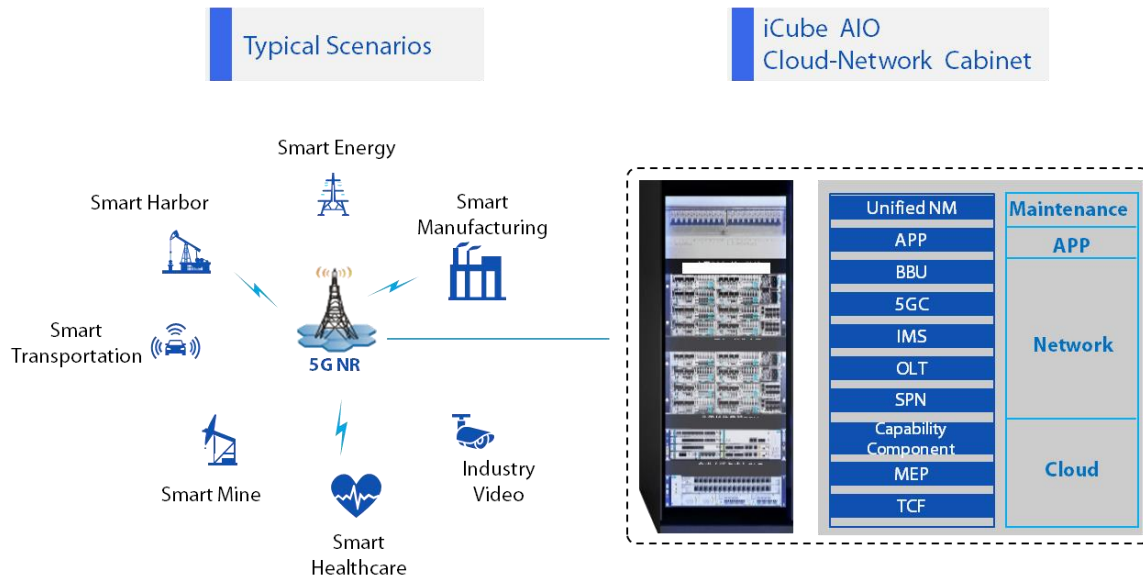

Figure 4-1   ZTE iCube Industry AIO Cloud-Network Solution

The iCube AIO cloud-network cabinet is the main form of the industry AIO cloud-network solution. It integrates cloud, network, industry application and maintenance for the campus private network scenarios, and satisfies the requirements of industries such as intelligent manufacturing, smart energy, smart port, smart transportation, mine, medical treatment and video for connectivity and computing. It can support

the integrated access of wireless and wired networks, and features such functions as industry voice, message and typical applications. It can also be deployed to enterprise campuses or mobile access equipment rooms on demand.

Cloud	Edge Computing Demand	Provides cloud infrastructure with dual-core engine of VM and container and MEC
Network	5G Connection Demand	Provides access of 4/5G, NB, fixed network OLT and SPN to meet the demands on large bandwidth, high reliability and low latency
Application	Prefabrication of Typical Applications	Supports on-demand loading of application components such as AI, big data and video, as well as typical applications such as AGV, machine vision, remote control and AR/VR
Maintenance	Network O&M	Flexibly provides remote O&M and local O&M

Multi-specification hardware model, flexible on demand deployment

Based on different scenarios, iCube has two models to provide differentiated network and computing resources for the industry.

➔ **Typical configuration model:** Cloud-network resources are deployed in the compact cabinet to provide 50,000 user access and 20Gbps forwarding capabilities to meet the requirements of private network construction in a campus.

➔ **High-configuration model:** The dual-cabinet cloud-network isolation mode is used for deployment. By default, it provides 100,000 user access and 50Gbps forwarding capabilities to meet the deployment requirements of super-large industrial applications.
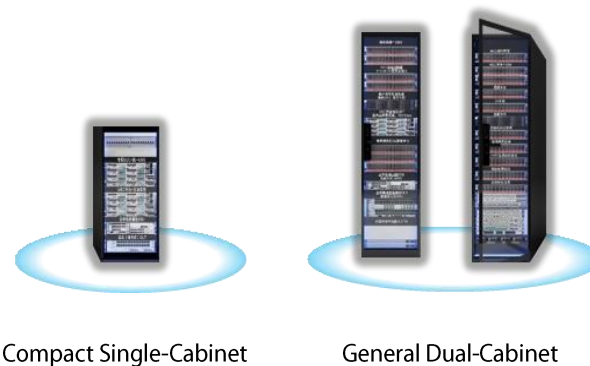
Compact Single-Cabinet   General Dual-Cabinet

Figure 4-2   Two Hardware Models of iCube

"Plentiful, Rapid, Good, and Economical", accelerating industry innovation

The private network system planned by the operator uses exclusive wireless network or spectrum. The core

network is customized to be deployed in the campus to meet the high-end requirements of industry customers for high isolation, ultra-high reliability, exclusive uplink, and exclusive resources. The iCube AIO cloud-network solution provides plentiful, rapid, good and economical one-stop solutions for digital transformation of industry customers.

➔ **Plentiful:** The unified integrated TCF supports multiple application scenarios with multiple network access (wireless and wired) modes and multiple heterogeneous hardware devices.

➔ **Rapid:** Rapid deployment is achieved through prefabrication before shipment. Unified network management and two-level O&M are used for easy and rapid O&M. Typical industrial applications and application capability components are preset to support rapid integration and onboarding of industrial applications.

➔ **Good:** The carrier-grade reliability architecture is used to build a high-reliability, low-latency, and determined network for the campus. The built-in soft firewall ensures network security and consume less resources.

➔ **Economical:** With unified hardware and unified resource pool, the one-stop solution can address network computing requirements, significantly reducing CAPEX. Integrated delivery and unified O&M significantly reduce OPEX. Modular function combination, application preset and equipment prefabrication make deployment and maintenance easy.

With the deep development of 5G network in the industry, AIO cloud-network solution is regarded as an integrated construction mode of the exclusive private network. Compared with the traditional separate construction approach, this solution will form an overall advantage in function, integration, deployment, provisioning, and O&M, so it will become an important solution for constructing the exclusive private network, facilitating the digital transformation, innovative network construction, and intelligent manufacturing demonstration factory construction of industrial enterprises.

5 Industry 5G O&M Solution – ToBeEasy

ZTE provides the ToBeEasy O&M solution for industry private 5G Core and industry 5G cloud-network. ZTE provides two O&M mechanisms: centralized professional O&M for operators/integrators/enterprises and campus self-O&M for integrators/enterprises, including centralized O&M EMS, local O&M LMT and enterprise self-O&M portal. EMS/LMT can provide the standard O&M system for northbound interconnection with operators, and the self-O&M portal can be provided for the local simple maintenance of the enterprise campus. The professional EMS/LMT centralized O&M or self-O&M can be selected according to different scenarios and different O&M objects.

The i5GC O&M system is oriented to the full lifecycle of enterprise O&M, including plug-and-play and rapid deployment of private network equipment. It provides all-round alarms, indicator monitoring, intelligent fault location, network optimization and version upgrade. It also provides enterprise-oriented self-O&M.

5.1 Plug and Play

To meet the requirements of rapid deployment, the i5GC deployment process follows the standard pre-configuration of general data, provides remote one-click modification for personalized data, so as to enable plug-and-play and rapid deployment of industry private network.
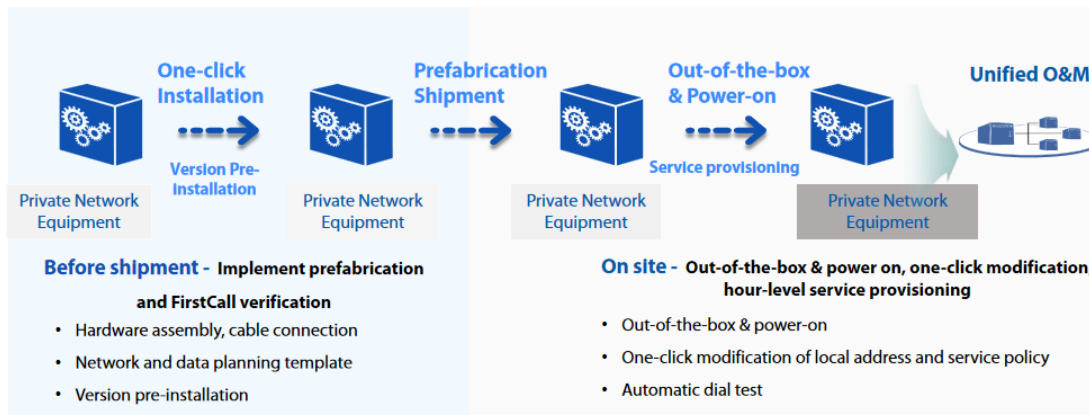

Figure 5-1   Plug-and-play for One-stop Commissioning and O&M of Private 5G Network

Standard prefabrication: Before delivery, the i5GC equipment automatically completes the automatic installation of standardized operating environment and software, and pre-configures general data..

One-click configuration: The prefabricated i5GC equipment supports automatic access to the equipment NM domain at the edge node. The NM domain automatically designs the configuration script of the i5GC equipment according to the specific on-site environment, and configures the personalized office data through the EMS.

Automation test: The EMS provides automatic test tools and encapsulates i5GC test cases and test tools, so that the O&M personnel select test cases according to different scenarios to implement automatic end-to-end test of i5GC services.

5.2 Professional O&M of Private Network

The maintenance function of i5GC is mainly for the network maintainer of the operator/integrator/enterprise, and requires the basic NE maintenance function. In some scenarios, NF equipment does not have EMS products with complete functions. In this case, an LMT system is required to manage the basic capabilities of NFs. Both EMS and LMT need to be lightweight and easy-to-use, and can meet the requirements for local provisioning, configuration management, signaling trace, log/alarm/security management, indicator monitoring, and troubleshooting.

5.3 Self-O&M Portal

In addition to the operator, the enterprise also needs to participate in the management of i5GC to complete network O&M through the cooperation of both parties. Operators focus on deployment, in-depth maintenance, and other operations with high technical requirements. Enterprises focus on managing their own applications and terminals, and monitoring network conditions, with general skill requirements for O&M personnel. As the enterprise O&M system, the self-maintenance service portal can help the enterprise carry out efficient O&M, manage enterprise terminals and APPs, and assist in network O&M.

The self-O&M portal provides multi-layer O&M for terminal devices, network channels, and enterprise applications, and provides comprehensive network monitoring and intelligent location analysis, helping users accurately understand the network service quality and rapidly troubleshoot network faults, ensuring stable service operation.
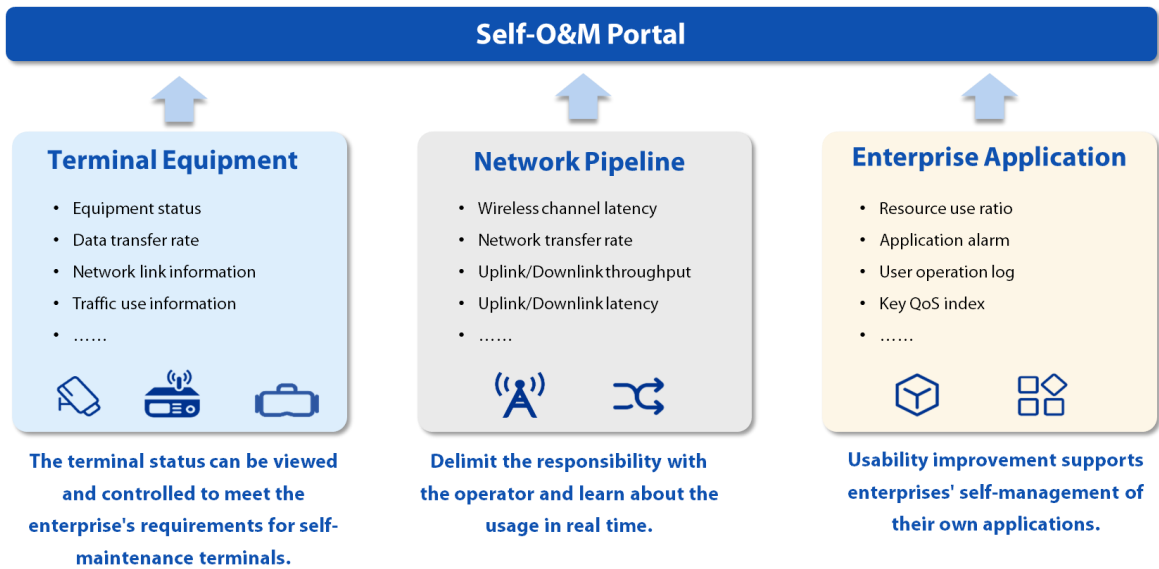
Self-O&M Portal

Terminal Equipment
- Equipment status
- Data transfer rate
- Network link information
- Traffic use information
- ......

The terminal status can be viewed and controlled to meet the enterprise's requirements for self-maintenance terminals.

Network Pipeline
- Wireless channel latency
- Network transfer rate
- Uplink/Downlink throughput
- Uplink/Downlink latency
- ......

Delimit the responsibility with the operator and learn about the usage in real time.

Enterprise Application
- Resource use ratio
- Application alarm
- User operation log
- Key QoS index
- ......

Usability improvement supports enterprises' self-management of their own applications.

Figure 5-2   Self-O&M Portal

➔ Monitors the running status, equipment traffic and equipment link quality of the terminal equipment;

➔ Monitors resource information and status of network channels, such as wireless channel latency, transmission rate and API invocation.

➔ Monitors various indicators of enterprise applications, such as network performance, user security logs and service QoS indicators.

Different from operators' O&M systems, the enterprise self-O&M portal is more simplified and flexible, greatly reducing the pressure on enterprise O&M.

➔ Simplified functions: It only provides basic functions such as network performance, resource monitoring and alarm handling, not including complex network operations such as NF instantiation and service configuration, thus reducing the pressure of enterprise O&M.

➔ Simplified interface: It supports user-defined large screen indicator. For example, only the TOP N indicator is displayed, or only the service SLA concerned by the enterprise user is displayed.

6 Industry Cases

6.1 Smart Healthcare

With rapid development of 5G, IoT, AI, MEC, big data and other technologies, the healthcare field is gradually evolving from informatization to intelligence. The characteristics of 5G network such as large bandwidth, low latency, and ultra-high reliability will become important technical means to promote the upgrade of application scenarios in the healthcare field. To further improve patients experience and the working efficiency of medical staff, a hospital in Jiangsu Province, together with the local operator and ZTE, explore the application of 5G + smart healthcare. This project deploys two sets of i5GC (1+1 redundancy) in the hospital area to build a highly reliable and independent private 5G network.

Up to now, two types of application scenarios have been commissioned preferentially in the hospital: Mobile office optimization, it can solve problems, for example, traditional WiFi only helps view text content such as medical advice, the images are frozen seriously, and the network security is poor. The private 5G network provides coverage for each department to meet the requirements for large bandwidth of images. Intensive mobile teaching and ICU visiting are implemented, to improve the efficiency of healthcare collaboration.
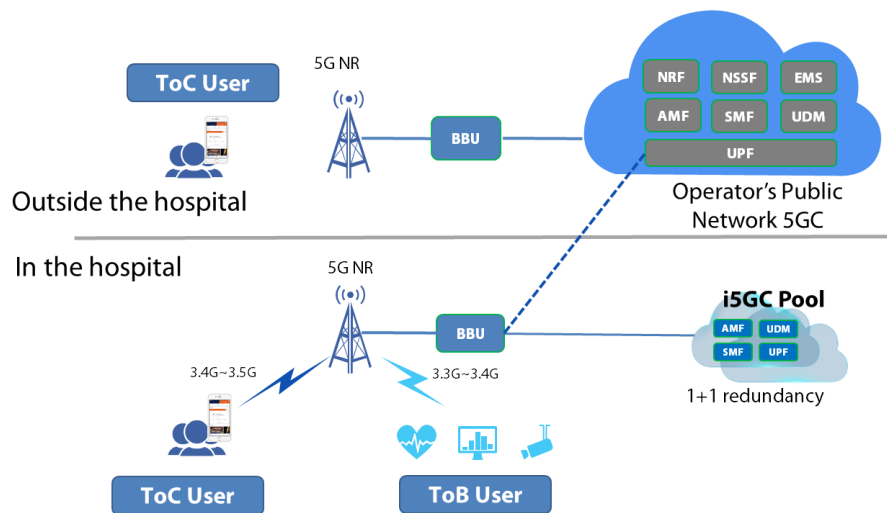

Figure 6-1   Private 5G Network Architecture of Smart Healthcare

This project has the following innovative advantages:

1. Compared with the public 5GC, the industry-specific i5GC is lightweight, compact and customizable. It features stronger equipment room adaptation, low consumption and low cost.

2. Due to the high reliability of network transmission for healthcare service, an i5GC pool, two sets of i5GC with 1+1 redundancy and load sharing, is deployed to achieve geographical redundancy. When an i5GC fails, all online services are uninterrupted, and new access services are not affected.

3. This solution provides a self-service portal, including network running indicators monitoring, alarm reporting, KPI viewing, daily maintenance, etc. The O&M personnel can adjust and optimize the network in real time according to the service. Enterprises can perform self-O&M or operators can replace enterprises to make maintenance.

Based on private 5G network, more healthcare application scenarios will be explored and deployed in the future, such as 5G remote emergency and 5G remote consultation. Through the remote, mobile, and information-based upgrade and transformation of the entire hospital office, we will create a more efficient, safer and smarter healthcare system, and accelerate the development of smart healthcare with 5G to enter a new stage.

6.2 Smart Mine

In traditional industries, mine plays an important role. With the gradual promotion of national policies on green mining, mining is gradually evolving towards intelligent mining with the help of 5G, automation, and AI technologies. Based on this, ZTE cooperates with operators and a mine in Shanxi to build a 5G smart mine solution. By deploying private 5G network in mining areas, it is possible to make digit-oriented, employ fewer people or even unmanned so as to improve production safety and efficiency, and reduce production costs.

1. This project deploys a private 5G network over the mine. A pool with two sets of i5GC to provide highly reliable communication for the mine. In complex working environments, a large number of environment monitoring and equipment monitoring devices have requirements for high bandwidth and low latency of the network. Based on private 5G network, it enables full interconnection with people, machines, and things in the mine. Up to now, the following applications have been implemented: intelligent coal mining, intelligent routine inspection, and unmanned mine carriage.

2. Based on the local deployment of UPF, the traffic offloading inside the mining area provides the basic communication network with low latency for auxiliary transportation of mine or unmanned mine carriages. According to the verification, the end-to-end latency is less than 20ms and the reliability is 99.999%. Through precise underground positioning and real-time images returned by HD cameras,

the dispatcher can accurately master the real-time conditions, thus achieving the locating, communication, control, scheduling, and navigation of the underground transportation system.

3. The lightweight IMS system is overlaid on 5G private network and interconnected with the mine voice in the existing network to meet the universal requirements of the mine voice, such as emergency broadcast, command dispatch, and intercom.

The mine has realized vehicle personnel locating, operation information collection, and automatic control of mechanical devices. At the same time, it uses advanced technologies such as intelligent identification, machine learning, and AI to replace "rule by man" with intelligent automatic management of the mine service. Relying on the i5GC, this mine implements innovative applications such as HD video monitoring, unmanned mine cards, intelligent excavation and 5G intelligent robot patrol, thus achieving that all personnel and all devices in the mine are connected to the Internet so that the mine can build an AIO intelligent system.
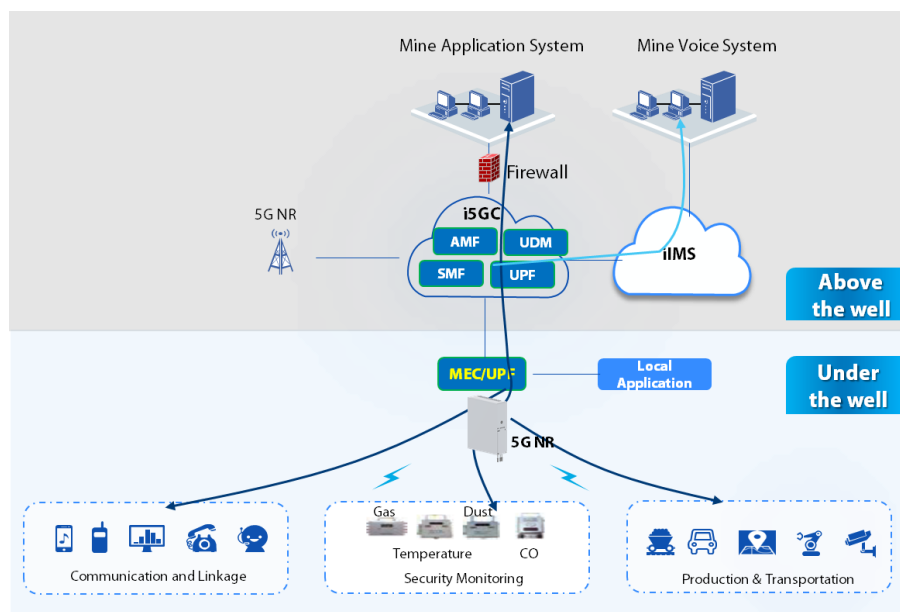

Figure 6-2   Private 5G Network Architecture of One Mine from Shanxi Province

6.3 Smart Manufacturing

As the manufacturing industry gradually transforms and upgrades to informatization, digitization, and intelligence. As the first batch of smart manufacturing pilot enterprises, SANY regards digital transformation as an important development strategy of the enterprise. The project puts forward higher requirements for the rapid integration of connection, computing power and applications. There is an urgent need for a solution with full integration, on-demand application and one-stop delivery.

Based on the industry iCube AIO cloud-network solution, ZTE and Beijing Mobile help SANY to set up a new type of cloud-network. This project is the first in the industry to realize the integrated deployment of cloud, network, application, and O&M. The solution accurately matches the service scenarios of campus, and loads innovative applications such as digital acquisition, machine vision, digital twins, crane remote control, cloud-based AGV, and integrated locating on demand, to promote the quality and improve the efficiency.

This solution realizes innovations in the following four dimensions:

➔ **Connectivity**: On-demand selection and flexible combination of BBU, i5GC, OLT and MEP devices in the campus provide ubiquitous access capabilities such as wireless and wired.

➔ **Computing power:** it provides heterogeneous hardware, unified TCF, and flexible and diversified application components.

➔ **O&M:** Based on ToBeEasy, the solution achieves unified management of NR, bearer and core network, and provides flexible local equipment O&M and customer-oriented self-service portals.

➔ **Ecology:** On the basis of AIO cloud-network, the AGV, machine vision, scheduling and management system, AR/VR and other industrial applications are integrated, enabling ICT innovation, and building a digital transformation benchmark for smart manufacturing.
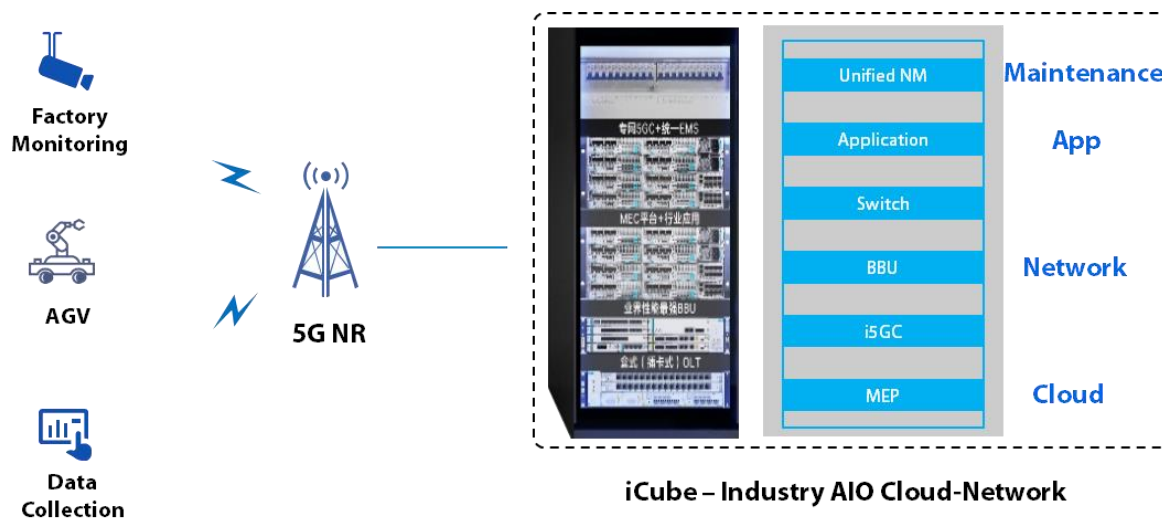

Figure 6-3   SANY Industry AIO Cloud-Network Architecture

Relying on the cloud-network integration in the 5G industry, ZTE further integrates 5G and park production, continuously promotes the implementation of the innovative application scenarios of 5G+ industrial Internet, and endows the manufacturing industry with new capabilities of automation, digitalization and intelligence.

7 Summary

ZTE provides private network solutions that are simplified and customized for different industries. With high cost-effective and fast deployment capabilities, Industry 5G Core Solution accelerates the implementation of 5G in various industries, and promotes the improvement of overall social and economic efficiency. With in-depth cooperation and innovation in various industries, the potential and value of 5G are constantly being unleashed. As an important link in the digital economy, 5G can provide high-quality and efficient infrastructure services for the industry.

Up to now, ZTE has carried out exploration of 5G applications with more than 500 partners in 15 key industries such as manufacturing, transportation, energy, media and health care, forming nearly 100 innovative 5G application scenarios.

In the wave of digital economy, ZTE positions itself as the builder of the digital economy, and provides products and technologies for the industry. ZTE adheres to the principle of "co-existence & empowerment, brand-new & opening-up," and work with industrial partners to redefine the industry through 5G to win the future of digital economy!

Leading 5G Innovations

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