ZTE

NodeEngine 2.0

NodeEngine2.0 Whitepaper

Building a Simplified, Intelligent, and Open Industry Private Network

TABLE OF CONTENTS

Action plan "Yangfan" for 5G applications, requiring industry-wide collaboration and innovation

The new-generation innovative ICT technologies, 5G as a leader, are increasingly becoming the key driver and engine for the economy and society to transform and upgrade toward a digitalized, network-based, and intelligence-based model, which give strong support to the construction of the manufacturing power and Internet power. After more than two years of construction, China has become a leader in global 5G construction and development.

In July 2021, the Ministry of Industry and Information Technology (MIIT), together with the Office of the Central Cyberspace Affairs Commission, the National Development and Reform Commission and other seven ministries, jointly released the 5G Applications "Yangfan" Action Plan (2021-2023). According to this plan, the state will vigorously promote new products, new business types, and new models for 5G applications, and provide strong support for digital transformation and upgrade and integrated innovation in all fields of economy and society. Objectives and action plans for the 5G+ industry development are clearly defined, facilitating the optimization of the industry environment, labor division, collaborative innovation and joint efforts, and finally continuously promoting the "sail" of 5G and 5G applications. This indicates that 5G is oriented to vertical industries and the scaled deployment of 5G applications has officially begun.

Dedication to industry scenarios, driving the continuous innovation of NodeEngine solution

In response to the extensive demands for the 5G private network, ZTE released the sole base station engine "NodeEngine" in September 2020. The NodeEngine extends the computing capability to the edge sites to assure the local data to be transmitted within the park, which easily facilitates the local private network. In March 2021, ZTE, together with China Mobile Research Institute, released NodeEngine WhitePaper, Enabling 5G Digital Transformation of Industrial Parks which systematically introduces the NodeEngine solution to help enterprises localize the digital applications of the park and ensure the security of production information with minimum cost and time. As of now, this solution has assisted three major operators in the wide application in industrial parks, port mines, smart social welfares, smart venues, and other typical scenarios. In the meantime, the understanding of service scenario requirements is getting deeper and deeper.

Pain points of industrial parks

- Traditional wired optical fiber cabling is difficult. When the production line is adjusted, the cost of re-laying the optical fiber is high.
- The uplink bandwidth of 4G is insufficient, so WIFI is easily to be interfered, leading to unstable delay and rate.
- Unified access is required by 4G modules and terminals.
- It is difficult to locate the inventory and equipment indoors, reducing the utilization rate of assets.
- Regarding the remote control of overhead cranes and shore cranes, the video backhaul delay is long, which affects the operation efficiency and accuracy.
- The cost of independent control of visual devices is high, and the computing capability cannot be shared.
- The coexistence of various networks and protocols makes it difficult and costly for enterprises to operate and maintain.

Pain points of port mines

- The shore cranes, overhead cranes and underground equipment move frequently while the wired link may be easily broken. If the 5G is used to transceive the control information, when the core network is disconnected from the base station, the communication between the underground control equipment and the terminals will be affected, resulting in urgent equipment stop or uncontrollable equipment.
- The power consumption of the core network equipment is very high, and it is impossible to prevent explosion and refit the mine currently. There is no data offloading capability in the mine. All the data is returned to the ground while some console equipment is just in the mine.
- High-precision positioning service is essential in the mine. A base station and platform for positioning is required. The deployment of the dual-system chimney for both positioning and communication is costly and difficult to manage.
- The remote control center and the equipment in the mine are usually covered by the enterprise Intranet. How to replace the original two-layer wired switching network with the 5G wireless system requires the interworking of two layers within the two Intranets.

The pain points of people's social welfares such as hospitals

- Difficulty in positioning: The mobile ward-round vehicle requires an accuracy of 2 to 3 meters. In traditional ways, the accuracy is about 5 to 8 meters, and an additional location server for uploading the location information is a must.
- High delay: A medical image is about 500 M or 600 M, which requires the downlink bandwidth to be higher than 300Mbps. If the distributed UPF is not available, it takes more than ten seconds to view the image, indicating a very high delay.
- Small bandwidth: The neighborhood monitoring are imposing higher requirements for cameras. Consequently, the 1080P/4K requires 8Mbps/16Mbps bandwidth respectively.

Pain points of smart venues

- Strong demands for smart services: Public venues are related to people's social welfares, which is one of the key tasks of the government. The user experience of smart services is vivid and direct.
- Demands for nomadic services: Similar to the electronic sports, rapid deployment is essential. With the ending of a competition, the network requirements are gone. In addition to wired deployment, traceless 5G deployment is required in many scenarios, and the overall deployment should be as simple as possible.
- Difficulty in indoor positioning: The venues are mostly indoors, so it is difficult to locate in the venues. The positioning and navigation services have not been well applied in the indoor venues.

Based on the analysis of the above pain points, ZTE found that the NodeEngine1.0 solution which was centered on local offloading no longer fully meet the service requirements in more scenarios. To better serve the industry customers, ZTE upgraded the NodeEngine solution in an all-round way.

New-architecture NodeEngine solution: 1+N+∞

To better match the requirements in different service scenarios and rapidly respond to the 5G network requirements of industry customers, ZTE has proposed the NodeEngine 2.0 solution based on the innovative "1+N+∞" architecture.

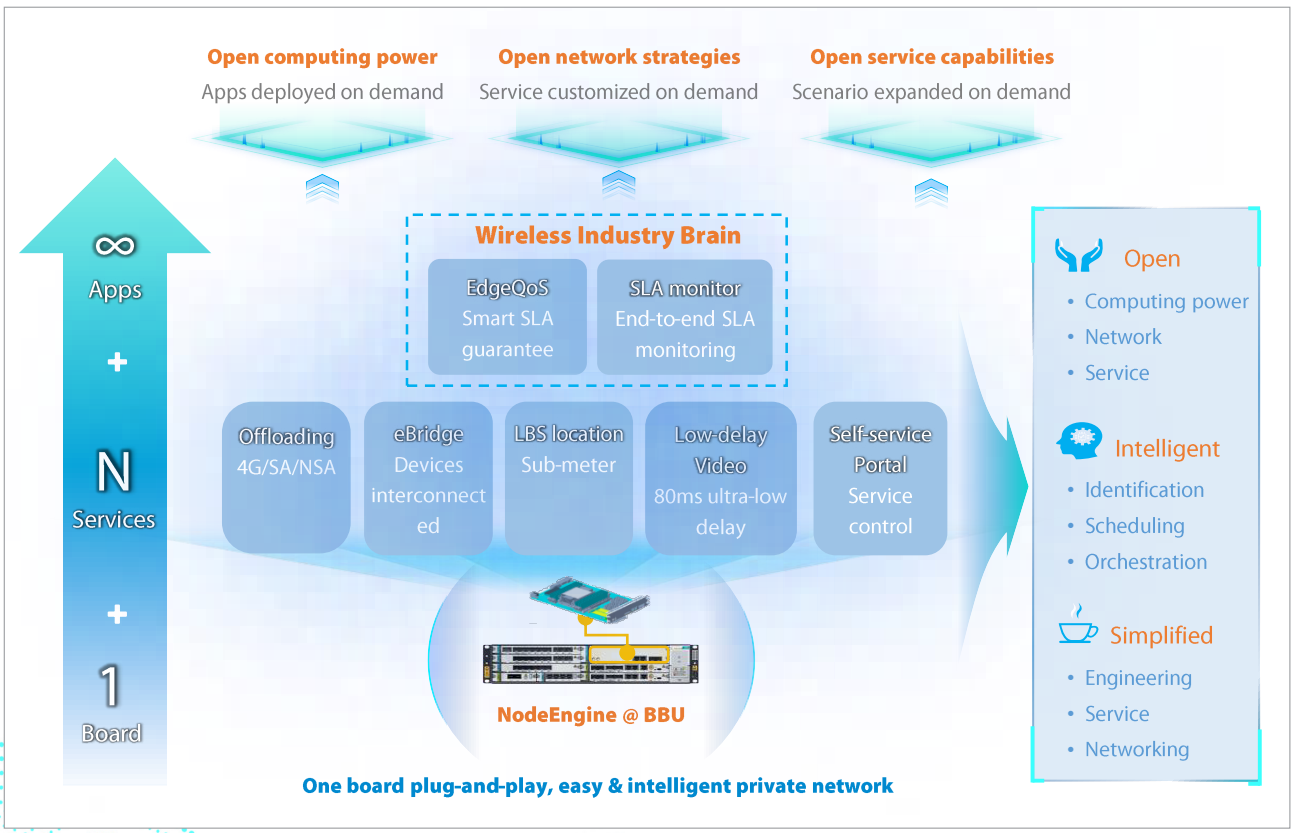


Figure 3-1 New Architecture "1+N+∞"

"1" represents "one board".

With only one board, the 5G private network can be built based on the distributed computing power, so that data is held within the park. At the same time, multiple NodeEngines are integrated to form a computing power resource pool to implement the elastic expansion of computing power, giving support to private network applications of higher performance and larger scale.

"N" indicates that the NodeEngine can provide services in "N" dimensions.

On the basis of the NodeEngine1.0, the NodeEngine2.0 improves the capabilities of various services in an all-round way. It provides multi-dimensional services of full integration, full systems, full networking scenarios, full intelligence, end-to-end, full application scenarios, full modes and full management and control.

"∞" indicates that the NodeEngine can support multiple application scenarios.

NodeEngine2.0 can be deployed on demand by opening the computing power resources and supporting the deployment of third-party APPs. Scenarios can be expanded on demand by opening the service capabilities such as positioning. Customized service policies can be achieved by opening the network policies such as offloading, bandwidth management and local SLA. The NodeEngine 2.0 can achieve the integration and connection of the cloud, network and industry, serving various application scenarios in an all-round manner.

Total update of NodeEngine2.0

Compared with NodeEngine1.0, NodeEngine 2.0 has been upgraded completely, as detailed in the following table.

	NodeEngine1.0	**NodeEngine2.0**
One Board	One board, 10Gbps processing capability	**Computing power**: elastic expansion and resource pool
N-dimensional Services		
Local Offloading	5G SA local offloading	**Full modes**: 4G, 5G NSA, 5G SA local offloading
eBridge	Interconnection of L3 terminals	**Full networking scenario:** Interconnection between L2 and L3. The terminals can be interconnected flexibly according to the specific networking requirements of the customer
EdgeQoS	Static configuration of SLA rules; one-way delivery of configuration	**Full intelligence:** Intelligent identification of service types and intelligent matching of scheduling policies can dynamically guarantee service quality
SLA monitoring		**End-to-end**: End-to-end SLA monitoring of services
Low-latency videos	Indoor video gateway product, with an end-to-end video transmission delay of 100 ms	**Full application scenario**: Supports low-latency video stream transmission in both indoor and outdoor scenarios, and shortens the end-to-end video transmission delay to 80 ms
LBS indoor positioning	Only the fingerprint algorithm based on field strength is supported to achieve a positioning accuracy of "sub-meter" level	**Full mode**: Besides the fingerprint algorithm based on field strength, the positioning based on the E-CID and UTDOA algorithms are supported. In addition, the integrated positioning technologies based on Bluetooth and UWB are supported to achieve a positioning accuracy of "sub-meter" level
Self-service portal "Porta"	On the local self-service portal, private network services can be viewed and configured	**Full management and control:** Besides visible and configurable, private network services can be controlled, and real-time management and control is performed for specific services
∞ Apps		
Open algorithm resources		**On-demand deployment of APPs:** Third-party APPs can be flexibly deployed
Open network policies		**On-demand service customization:** APP-level and user-level local traffic offloading policies, traffic management policies, and local SLA policies are open
Open service capabilities		**On-demand scenario expansion:** Positioning capabilities are open to third-party positioning APPs in various industries

Building a simple, intelligent, and open industry private network

Benefiting from the leading "1+N+∞" architecture, the diversified and personalized customer demands are fully satisfied. In addition to the basic capabilities such as "data kept within the park," "multi-type terminal access," "precise network capability," "self-service" and "cost efficiency," the NodeEngine2.0 has another three features: Network engineering commissioning, service subscription and network simplification. Network connections are intelligent, and wireless network capabilities are open.

Simplified network

Simplified engineering commissioning, enabling one-hour commissioning of the private network

Traditional 5G private networks are usually deployed with distributed core network NEs, which requires new and independent NE equipment. Complicated networking, long deployment period, huge network construction and maintenance costs are often discouraging the small and medium-sized enterprises, which greatly limits the promotion and available scope of 5G private networks. In contrast, the NodeEngine solution, which adopts the innovative BS-centered design, simplifies the engineering, and can be summarized as five "one":

One board

With only one new board added to the existing BBU, the 5G private network can be built based on the distributed computing power. No engineering survey or equipment room reconstruction is required, saving the cost of private network deployment.

One pair of optical fibers

With only one new pair of optical fibers to implement the interconnection between the NodeEngine and the existing network equipment, the network deployment is extremely simplified and does not affect the existing BS services.

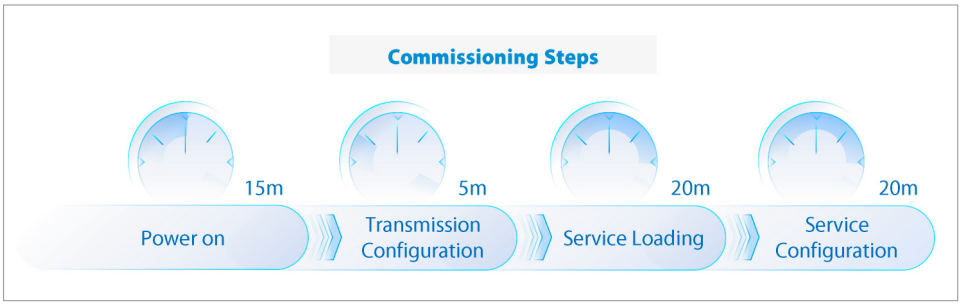


Figure 4-1 One-hour commissioning

One hour

It takes only one hour to complete the entire deployment, including power-on, service loading, and configuration, so that services can be launched.

One pair of IPs

With only one new service IP address and one management IP address to implement data interconnection, saving IP resources and avoiding complicated IP address application procedures.

One-hop transmission

Local service data is transmitted directly to the Intranet server of an enterprise through one-hop. In this way, the data transmission path is the shortest, effectively reducing the delay and fault risks.

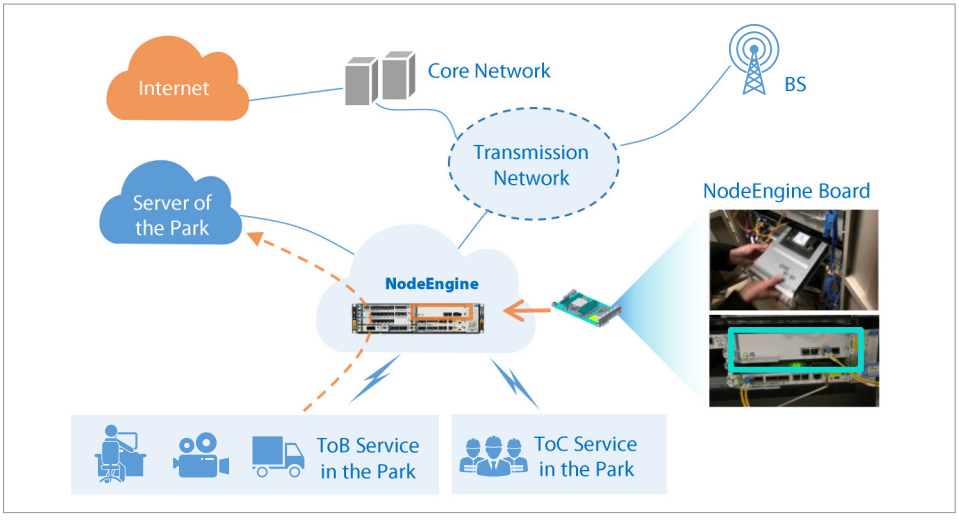


Figure 4-2 One-hop data transmission

Simplified service deployment, random insertion of white card devices

The NodeEngine solution is capable of flexible local service configuration, which can greatly ease the on-site services. SIM card subscription is a prerequisite for services in a traditional network. Only through the subscription procedure can the corresponding differentiated services be provided for different terminal users. The subscription flow of a specific 5QI involves multiple NEs, base stations and terminals in the core network, so a large number of messages need to be exchanged, which makes the flow quite time-consuming. In addition, since the information changes involve multiple related NEs, once the configuration is completed, it is very difficult to modify the service type. What's more, the SIM card, CPE and industrial equipment must be bound strictly, which means any mismatch or change will affect the service guarantee.

The NodeEngine supports the innovative default subscription of the white card, that is, to configure the mapping relationship with the specific service through the local self-service portal. When the service is launched, the NodeEngine provides the specific local private network service for the corresponding terminal through intelligent service identification and scheduling policy matching. This not only eliminates complicated subscription flow, but also decouples the SIM card from CPE/industrial equipment. That is to say, the SIM card and CPE/industrial equipment can be matched at will, which greatly simplifies the subscription flow and service deployment of the operator, and the local service change does not affect other NEs. The NodeEngine can change the service type in real time according to the customer's requirements, achieving real simplified service.

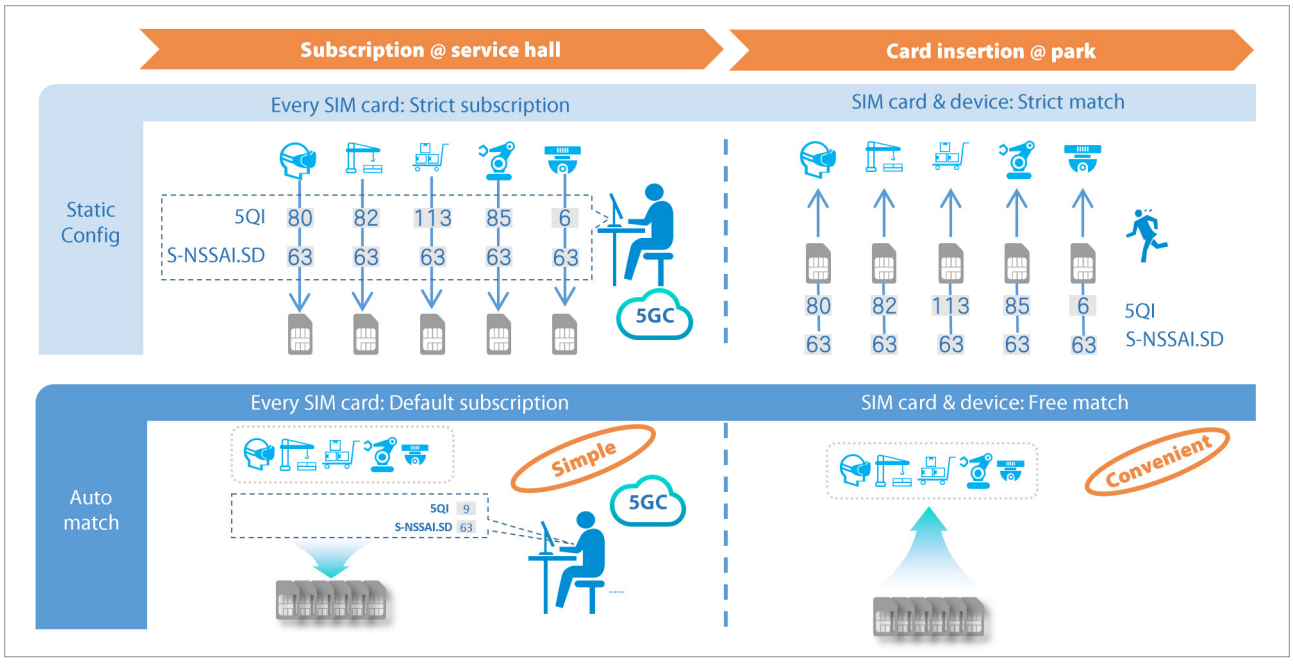


Figure 4-3 Free from subscription for white cards, free insertion

Simplified networking to flexibly adapt to all scenarios

Integrated 4G/5G, capable of all services in one network

In the 4G era, private networks have been built for some enterprises, and related services have penetrated into daily production and life, playing an enormous role. If a new network is built just for 5G services, both equipment and manpower costs will be considerably high. In addition, there will be coordination and management problems between the existing 4G services and new 5G services, which will affect the promotion and application of 5G private networks to some extent.

The NodeEngine provides a one-stop network solution. With only one set of equipment and one set of NM system, it can take into account both 4G public network/private network and 5G public network/private network services at the same time, and provide seamless service experience. Thus, the greatest concern for deploying a new 5G private network in the existing one is cleared, and new services can be introduced faster and more cost-efficiently, improving the production efficiency. At the same time, the existing 4G terminals can be multiplexed to the maximum extent, and the application scenarios for 4G/5G terminals can be flexibly allocated according to the specific service requirements to optimize the overall cost-effectiveness.

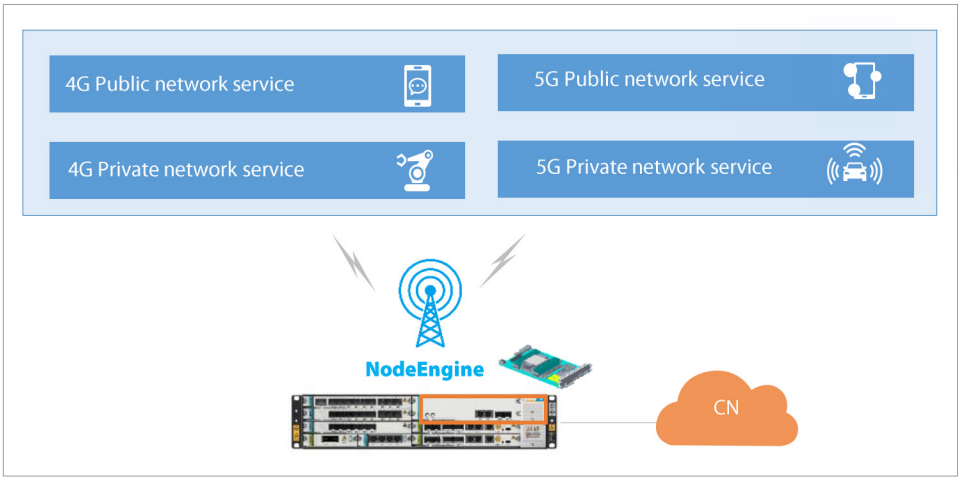


Figure 4-4 Integrated 4G/5G, capable of all services in one network

Independent operation in isolated scenarios

In scenarios such as coal mines and ports, the link between the local network and the remote core network may be disconnected due to uncontrollable reasons such as tunnel collapse, earthquakes, and typhoons. Sometimes, the local private network may lose the connection with the core network due to improper construction or mishandling. In this

case, it is very important to ensure that local services can still operate properly without being affected by link disconnection in an isolated scenario.

The NodeEngine ensures the proper processing of timers engaged and the local service is not interrupted when the communication with the core network is disconnected. At the same time, the private network data is isolated from the public network data on the user plane, ensuring the normal operation of the local service and leaving a time window for link repair. Please note that only the existing local services can operate properly, while the public network services related to the real-time core network still cannot be provided.

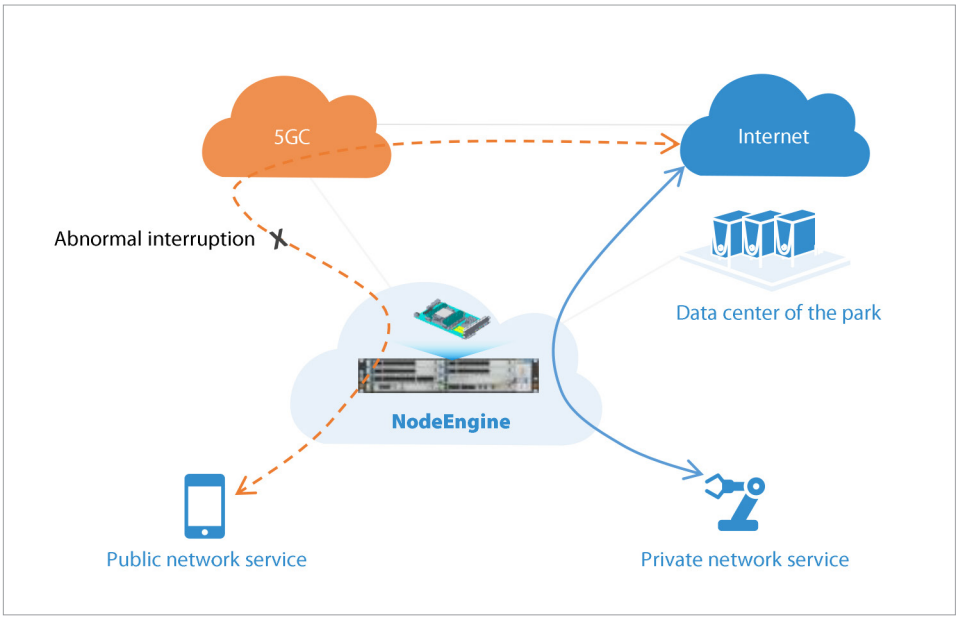


Figure 4-5 Independent operation in isolated scenarios, services not interrupted

Nomadic Base Station

With the diversification of 5G applications, operators often face the needs for temporary coverage, such as large-scale gatherings, exhibitions, emergency communications, and emergency rescue, featured with "emergent but flexible". How to quickly enable 5G-related services based on local conditions by making full use of the existing backhaul is a key issue. In view of this, ZTE has proposed the NodeEngine solution with nomadic BSs, which can be used directly on the BS for local distribution and local applications. It features simple networking, high equipment integration, fast network construction and convenient service provisioning, and in the meantime it is capable of local private network services and public network services. Nomadic BSs deal with the temporary coverage efficiently and cost-effectively.

For the backhaul part, the NodeEngine supports three modes, and the operator can select flexibly according to the actual situation.

Regarding the scenario where an enterprise network or public Internet has been deployed, a dedicated tunnel can be established through the NodeEngine to deal with the backhaul. It is applicable to enterprises, venues, conferences, etc.

The public network relay is used, and the wireless relay gateway/CPE is used to provide the BS backhaul. It is applicable to emergent communication, mobile exhibition hall and temporary stadium performance, etc.

The satellite network is used to handle the backhaul and the signaling transmission with the core network. At the same time, the NodeEngine is used to ensure local large-capacity applications. It is applicable to emergency rescue and etc.

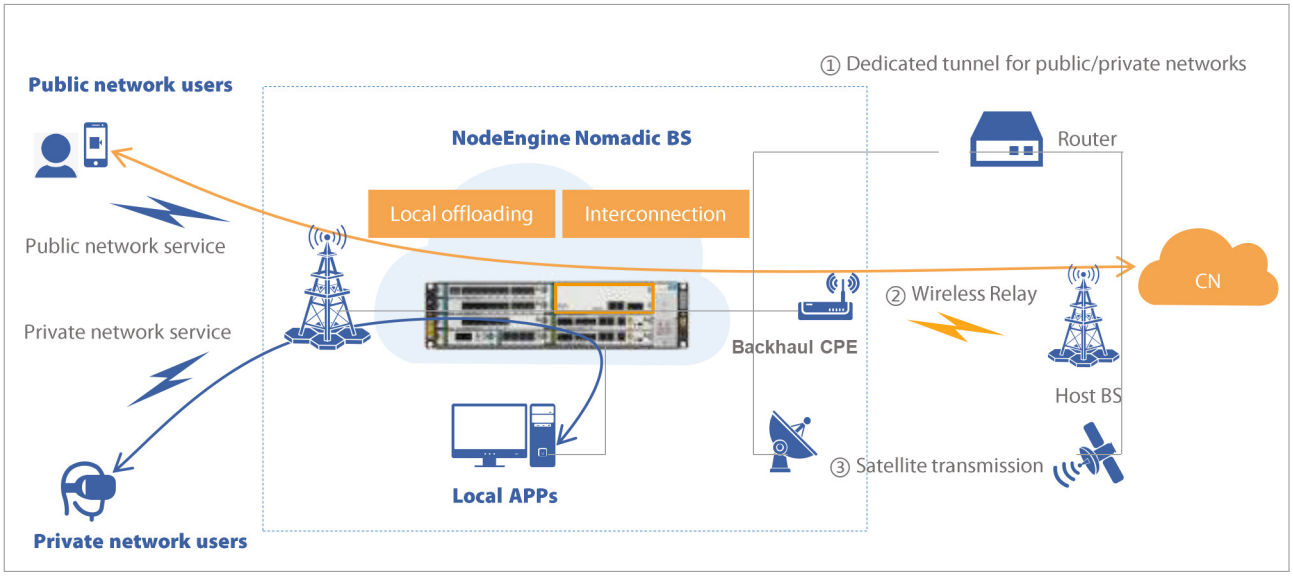


Figure 4-6 Nomadic BS, movable private network

Finally, thanks to the leading embedded architecture of the BS, the NodeEngine greatly reduces the equipment configuration requirements of the private network compared with those of the small 5GC and the edge UPF solutions. Thus, it has obvious advantages in the equipment size and footprint, and significantly reduces the equipment room. On the other hand, only one new board enables the NodeEngine solution to have very low energy consumption. Regarding the same 10Gbps throughput, the newly-added energy consumption of the NodeEngine BS is merely 200 W, much lower than that of the small 5GC solution and the edge UPF solution. This perfectly matches the development requirement of "green 5G" and greatly saves OPEX for operators and industry customers.

Intelligent network

The NodeEngine introduces AI intelligence, which enables an ordinary BS to evolve to an intelligent one. The innovative intelligent service guarantee solutions - "intelligent service identification," "intelligent service dispatching" and "intelligent service orchestration" create a wireless industry brain that can better understand service features and application scenarios for customers. The solutions include:

Self-service portal

It imports SLA guarantee requirements, such as possible service locations, network features, and the display of the guarantee results. In most cases, enterprise O&M personnel is responsible for importing the guarantee requirements and observing the effects through the enterprise's self-service portal.

Intelligent service identification

The SLA requirements imported by the users are analyzed and the network services are perceived continuously. When there is a service flow that accesses the local service APP, the AI deep learning is performed through the AIE engine and the IPI engine to get the service type and features. Through comprehensive analysis, the guarantee strategies requiring network guarantee are obtained and then scheduling and adjustment is made to guarantee the service.

Intelligent service schedulingA

It implements the guarantee strategies analyzed to meet the SLA guarantee requirements of services. EdgeQoS will implement SLA guarantee based on the determined network resources, so as to make good use of the existing resources for service scheduling.

Intelligent service orchestration

For the service SLA that needs to be guaranteed, the SLA Monitor will continuously monitor and measure the basic network indicators, and make comparison to check whether the target is achieved, so as to make closed-loop guarantee or guarantee optimization in time, and perform the display and feedback of the guarantee. In addition, intelligent service orchestration will be triggered on demand to guarantee streamline service SLA.

Taking the industrial park as an example, the NodeEngine can receive the SLA requirements for services to be guaranteed through the self-service portal of the enterprise or the API opened by the operator to the enterprise. When local data offloading is deployed, based on the local distributed data, it can learn and get the service features from the local service apps, such as AR vision, AGV navigation and remote control apps, as well as the UEs that will be connected to the enterprise apps. According to the SLA requirements to be guaranteed, the

SLA requirements and service features learned (such as the packet size and packet period) can be converted into the scheduling strategy of the wireless network. The deterministic network capability provided by the BS (such as flow scheduling based on dynamic 5QI, PRB resource reservation and RRM pre-scheduling indication of wireless resources) can be invoked to deliver the scheduling indication to the BS. Thus, the service scheduling can be differentiated and adjusted to meet the SLA requirements of enterprise applications. At the same time, SLA Monitor will continuously monitor, for example, the end-to-end service delay, calculate the delay achievement rate, and continuously monitor and give feedback to strategy engine for further closed-loop guarantee. At the same time, a self-service portal is provided so that the SLA can be defined, guaranteed, viewed, and positioned.

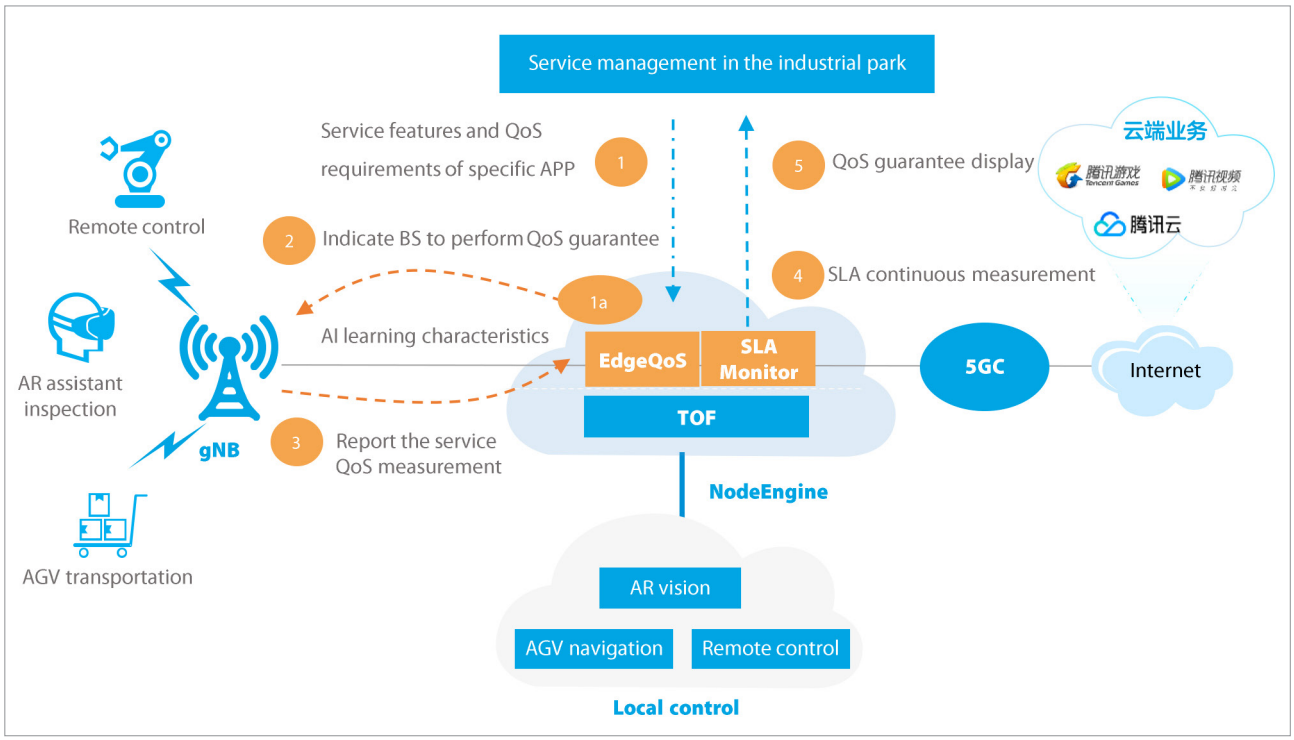


Figure 4-7 Intelligent SLA guarantee

Intelligent service identification: AI identifies service features and intelligent match of scheduling strategies

In industrial application scenarios, there are a variety of service types, which differ a lot. To achieve the SLA guarantee in a wireless network, it's necessary to accurately understand service features and SLA guarantee requirements of each service, flexibly match applicable wireless resource scheduling, and dynamically adjust related scheduling parameters to achieve the expected result.

The 5G QoS framework is based on the QoS flow, indicating that the QoS attributes and

parameters required by the service are statically subscribed and configured in the core network, so that the user can obtain the corresponding QoS indication when initiating the service. In the industrial scenarios, due to the service types, service differences and the rapid changes, the efficient and accurate service guarantee can hardly be achieved through static subscription of slice +5QI and configuration of QoS attributes and parameters. Therefore, dynamic service flow identification and further service feature identification should be considered.

The NodeEngine can not only identify the service stream, but also identify the service features of streamline and allocate the service features with radio resource scheduling functions and parameters, thus further improving the radio resource utilization efficiency.

Generally, various protocol features of packets are analyzed, extracted and identified based on DPI. Moreover, by introducing the AI engine, the NodeEngine system will further learn and deduce the service flow by using the neural network algorithm: To learn in advance the packet features of a specific service to obtain the service feature model, then deploy and deduce online to obtain the service features.

For example, for video service stream, the system can identify the packets corresponding to the I frame and P frame, and further identify the corresponding packet period, packet size and packet arrival time, so as to guide the BS to execute different scheduling strategies for the I frame and P frame. With the identification of service features like this, the service experience can be finer.

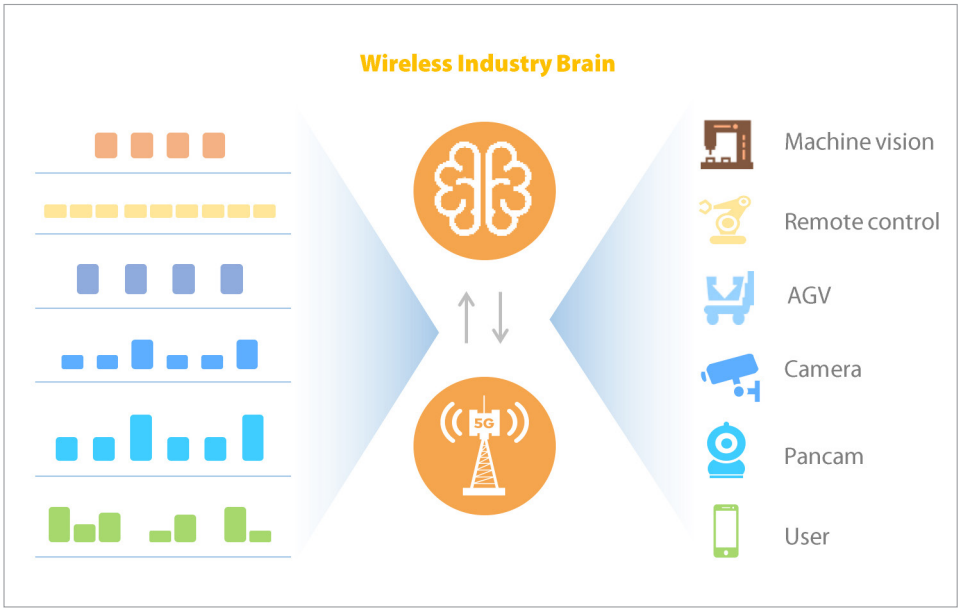


Figure 4-8 Intelligent identification of service types

Intelligent service scheduling: Guarantees SLA with optimum resources based on service flow features

In industrial scenarios, key services often impose extremely high requirements upon network transmission delay and reliability. Wireless networks need to provide necessary SLA guarantee solutions, which not only support intelligent service identification, but also affect wireless scheduling and even service orchestration based on the identified service features to implement efficient SLA guarantee.

After the NodeEngine identifies the service dynamically, it will select the best scheduling strategy according to the service identification result, and optimize the scheduling in a closed loop according to the KPI measurement result at the flow level, and finally achieve the SLA guarantee of the service.

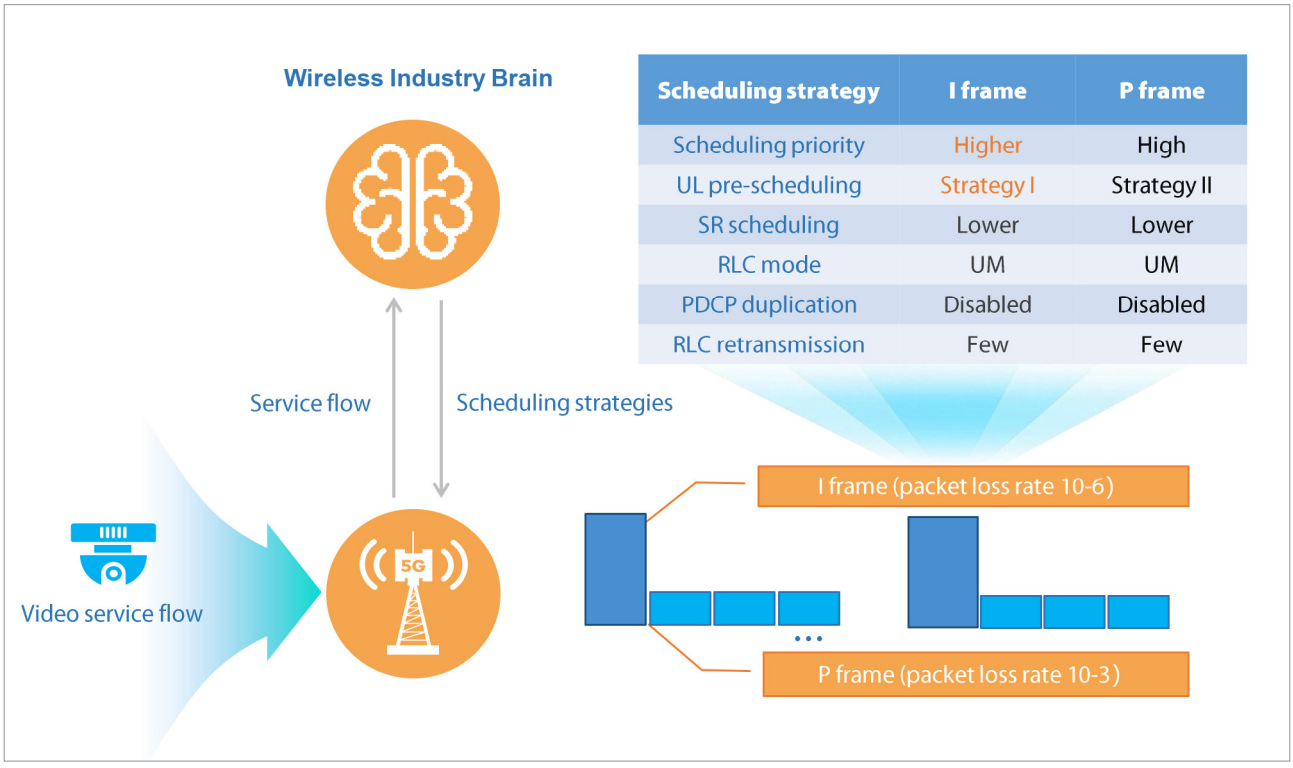
The following strategies are considered in industrial scenarios:

Intelligent adjustment of service priority

Based on intelligent service identification, this feature further dynamically adjusts service priorities in industrial parks in accordance with the service changes and SLA requirements.

Enhanced intelligent pre-scheduling

On the basis of intelligent service feature identification, the pre-scheduling start time is further dynamically adjusted to match the actual uplink service data transmission time to reduce the uplink data transmission delay.



Scheduling strategy	I frame	P frame
Scheduling priority	Higher	High
UL pre-scheduling	Strategy I	Strategy II
SR scheduling	Lower	Lower
RLC mode	UM	UM
PDCP duplication	Disabled	Disabled
RLC retransmission	Few	Few

Figure 4-9 Intelligent scheduling

In industrial scenarios, the wireless network needs to provide service-level performance statistics to meet the service monitoring requirements of industry customers. Industry customers require that the data transmission requirements of each service are met, and the each service flow should be measured to effectively monitor service experience. Many industrial applications are used for the communication between machines. The service flow performance statistics provided by the wireless network can effectively show the service status.

Under the QoS framework of 5G based on QoS flow, the flow-level performance statistics are provided for each QoS flow. The main indices are as follows:

- Service rate (uplink, downlink)
- Packet loss rate (uplink, downlink)
- Delay distribution (uplink, downlink)

By continuously measuring and monitoring service flows, the SLA requirements of services are expected to be met. If not, further analysis and optimization will be made, new scheduling strategies will be provided and service flows will be continuously monitored to ensure SLA.

Intelligent service orchestration: Segmented/ staggered orchestration of service flow, ensuring SLA

For most industrial scenarios, there are more uplink services and fewer downlink services. Typically, video monitoring, machine vision, and remote control services require a large amount of uplink bandwidth. In addition, services of different cameras may be required simultaneously. The extreme requirement for uplink bandwidth can reach up to hundreds of Mbps or even up to gigabit. In this case, the network needs to distinguish services based on different service features to orchestrate services in order with the SLA guaranteed.

The NodeEngine intelligent SLA guarantee will continue to adjust the scheduling strategy through intelligent service identification, intelligent service scheduling and continuous SLA measurement. For some services that cannot be well guaranteed, intelligent service orchestration will be performed. Through the operation of the following two strategies, intelligent service orchestration can better meet the SLA requirements with the same resources.

Strategy I: Staggered service

On the basis of intelligent service identification, the NodeEngine intelligent SLA guarantee will implement orchestration of staggered services when necessary through intelligent analysis, so that the services can be transmitted in a staggered order.

The video camera captures the physical world and distributes with I and P frames. Typically, in the video transmission scenarios mentioned above, the video I frame conflict occurs. When the instantaneous transmission exceeds the uplink bandwidth of the cell, it is necessary to make intelligent orchestration to ensure that the camera with UE/CPE can stably transmit the video in a staggered order. In this way, the network bandwidth is efficiently used.

Similarly, in the above scenario, compared with the I frame of video streams, the traffic of the P frame is smaller, and the impact on video viewing is smaller. This is because traffic with different service features has different requirements and impacts on service bandwidth.

Strategy II: Service splitting

Streams with different service features may have different requirements for bandwidth and delay. That is, for one type of service, one service stream may impose high requirement for bandwidth but low for delay, while another stream may impose low requirement for bandwidth but high for delay. For example, the signature board connected to the local terminal in the hospital has low requirement for bandwidth but high for delay, while the drug directory transmission has high requirement for bandwidth but low for delay.

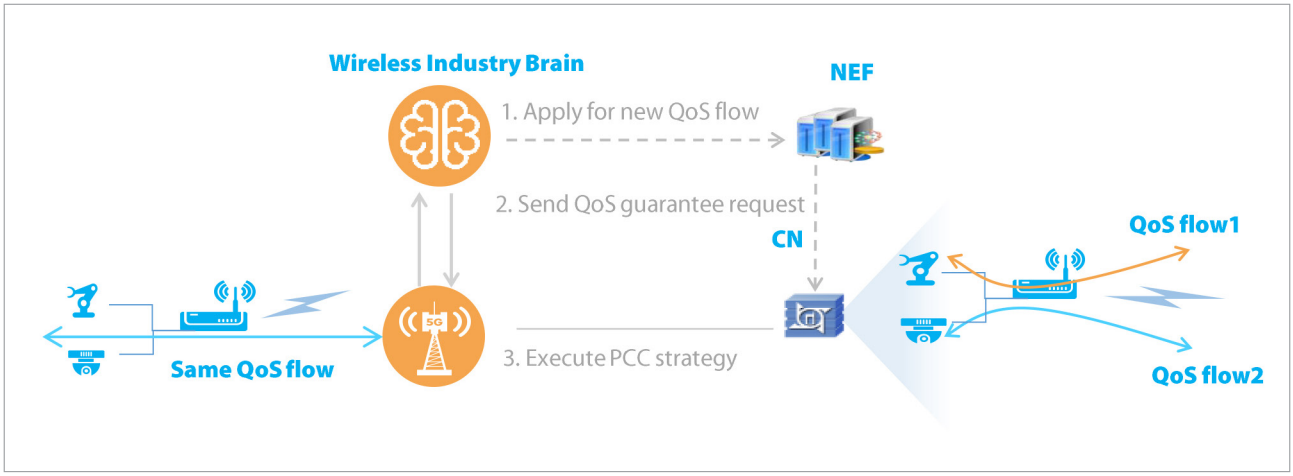


Figure 4-10 Service splitting

Different service flows require different QoS. However, 5QI is the default configuration when the SIM card subscribes. Regarding this scenario, splitting is implemented. That is, put all the default services into the session of the same QoS flow, and split them into different QoS flows required by the SLA of the service flow. Typically as mentioned above, the I frame flow and P frame flow are split, or the handwriting board flow is converted into different QoS flows.

The NodeEngine intelligent SLA guarantee solution can provide different service cycles for the services that require staggered orchestration, and will also configure different priorities for the split QoS flows so that a more exquisite scheduling strategy can be used to better guarantee the SLA.

Open capabilities

With the gradual application and maturity of 5G in various industries, the traditional "network connection" cannot meet the requirements of industry applications, and 5G networks need to be more open. Therefore, combined with the characteristics of the private network in the 5G industry, NodeEngine2.0 provides such resources as computing, storage, network and accelerator on the BBU shelf. Centered on the intelligent BS engine, it extends the computing power to the service site, thus enabling the wireless network capabilities to open to the private network in the industry. See the following figure.

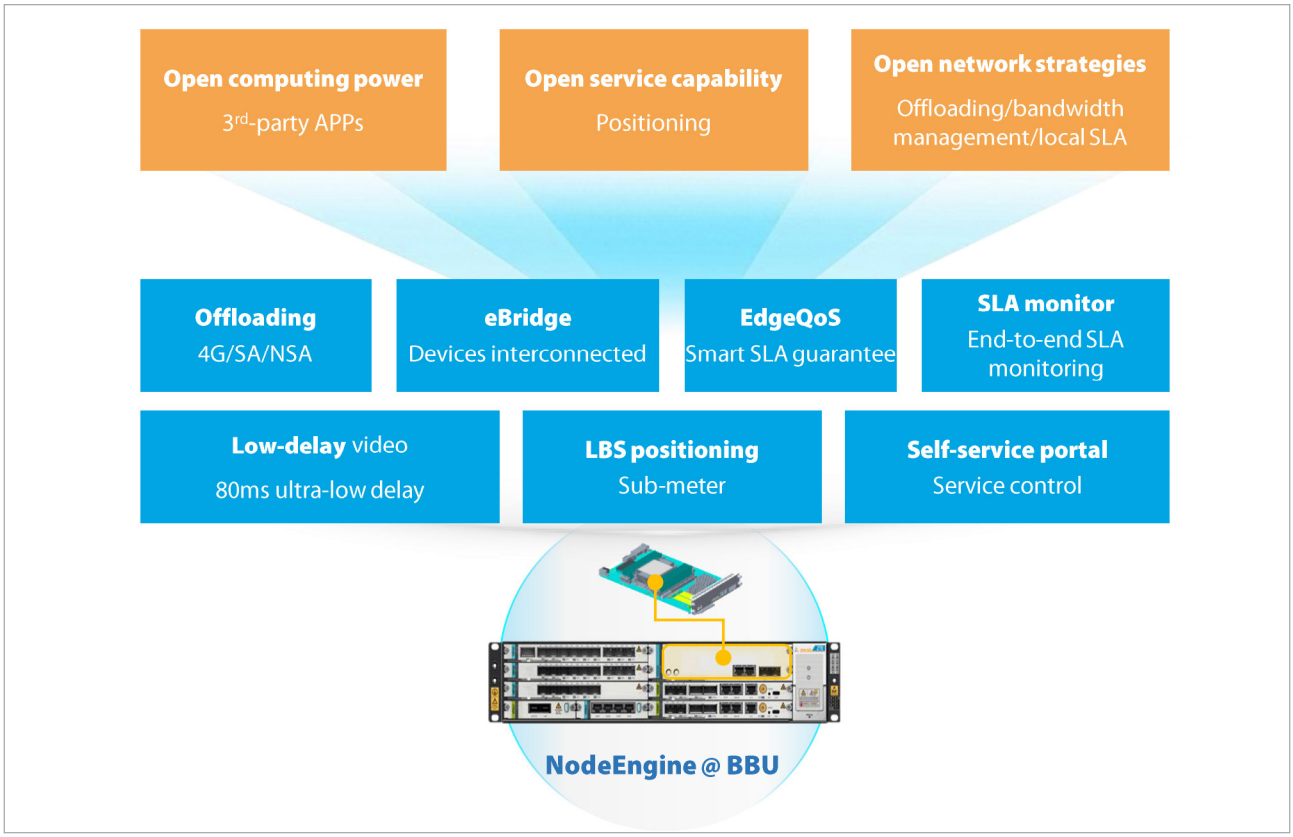


Figure 4-11 Open capabilities

Open computing power resources, applications deployed on demand

In-depth integration of 5G industry private networks with vertical industries will accelerate application innovation, change production modes and improve efficiency, and support sustainable increase in production efficiency in vertical industries.

The NodeEngine promotes cloud by network. While locally unloading traffic, it implements flexible computing and storage expansion. Through light cloud infrastructure, it provides open computing resources and operating environment for industrial applications such as data collection, video transcoding distribution, machine vision and safety helmet detection. At the same time, it can connect to the orchestration and management center of operator's edge computing service through open interfaces to implement rapid establishment of enterprise applications. By deploying online management and capability opening management, ZTE has created a new cloud-network integration solution to guarantee industry customers a convenient access to operators' cloud resources. This achieves one-point access, enabling customers to enjoy end-to-end cloud-network integrated services.

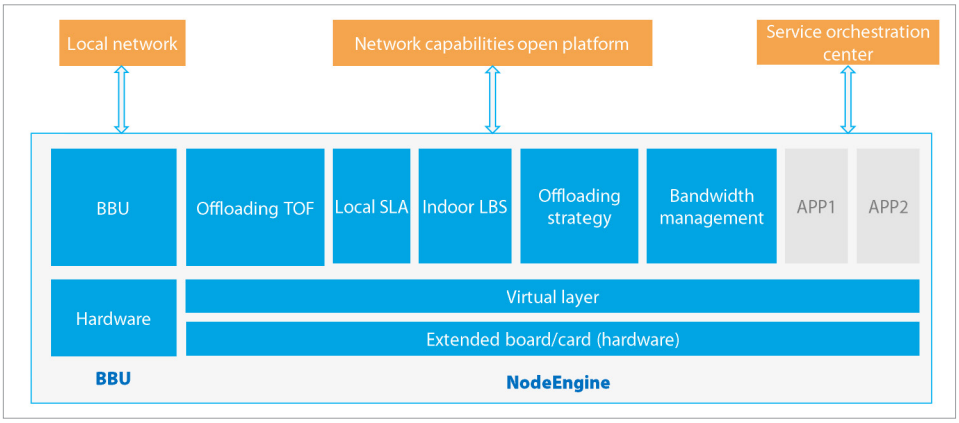


Figure 4-12 Open computing power

Open network strategies, customized services

Open offloading strategies

For the services related to production in enterprise parks, such as collecting the data generated by sensors, commands to control industrial devices, and monitoring information of industrial park devices, the security requirements are high. The services can be accessed only after exclusive authorization. In addition, the services need to be isolated from public networks, which means private network transmission is required, and production data must be kept within the park. Therefore, how to flexibly and efficiently offload service data streams is of high priority.

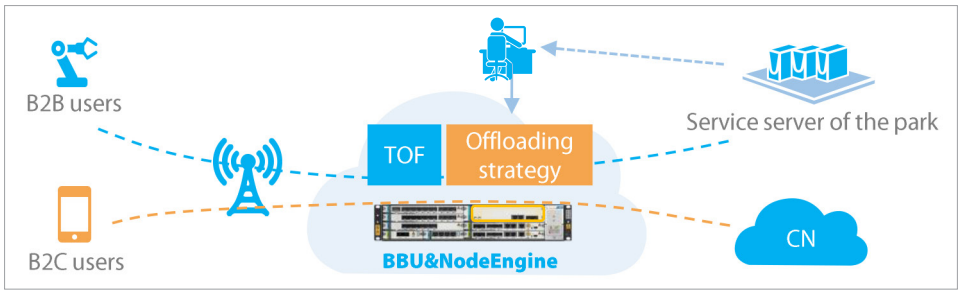


Figure 4-13 Open offloading strategy

The industry private network flexibly customized by NodeEngine can support local traffic offloading of 4G/5G services at the same time, and provide multiple local traffic offloading solutions. Open external capability interfaces are provided for industry customers, and flexibly configures local service offloading rules based on slice IDs, PLMN network IDs, IP 5-tuple, and DNS domain names. Industry customers can configure offloading rules through open capability interfaces, and deliver the corresponding rules to the network. The network implements dynamic and accurate offloading to ensure that data is kept within the park and is isolated from the public network. This feature meets the service access requirements of the industry private network in different scenarios.

Open offloading strategies

In an industrial private network, different local services, such as OA office, remote control, and video monitoring, have different bandwidth requirements. The access bandwidths of different terminals of the same type of services are also different. Therefore, service applications or users must be able to manage the bandwidth.

The NodeEngine provides the bandwidth management capability of APP level and user level, and opens the bandwidth management to the industry customers through the capability opening interface. The industry customers can flexibly configure the uplink and downlink bandwidth limit of the APP level or the user according to the service requirements.

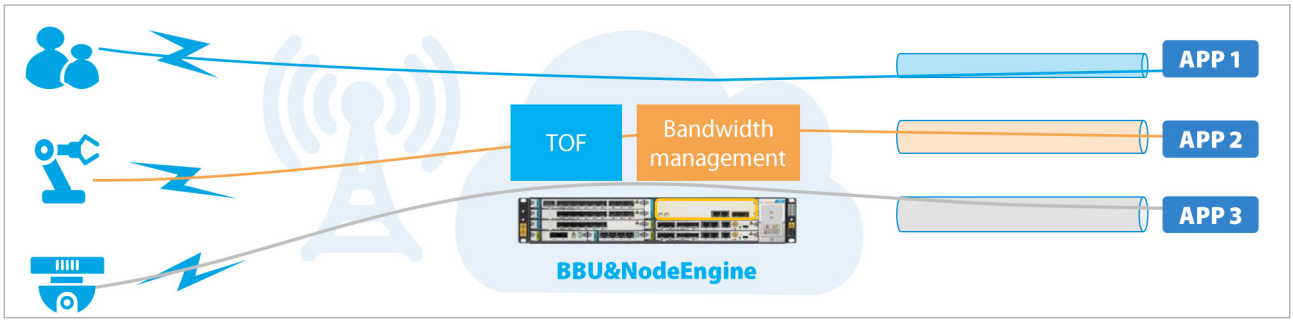


Figure 4-14 Open bandwidth management strategy

Open local SLA strategy

In an industrial private network, different local services have different requirements for bandwidth, delay, packet loss rate, jitter, and availability. Therefore, different services require different SLA guarantee. In actual projects, most industry customers cannot clearly tell the SLA requirements for various services. Therefore, accurate SLA subscription cannot be implemented for services during number allocation. As a result, during actual service operation, the network cannot match service requirements and cannot really play the role of 5G networks.

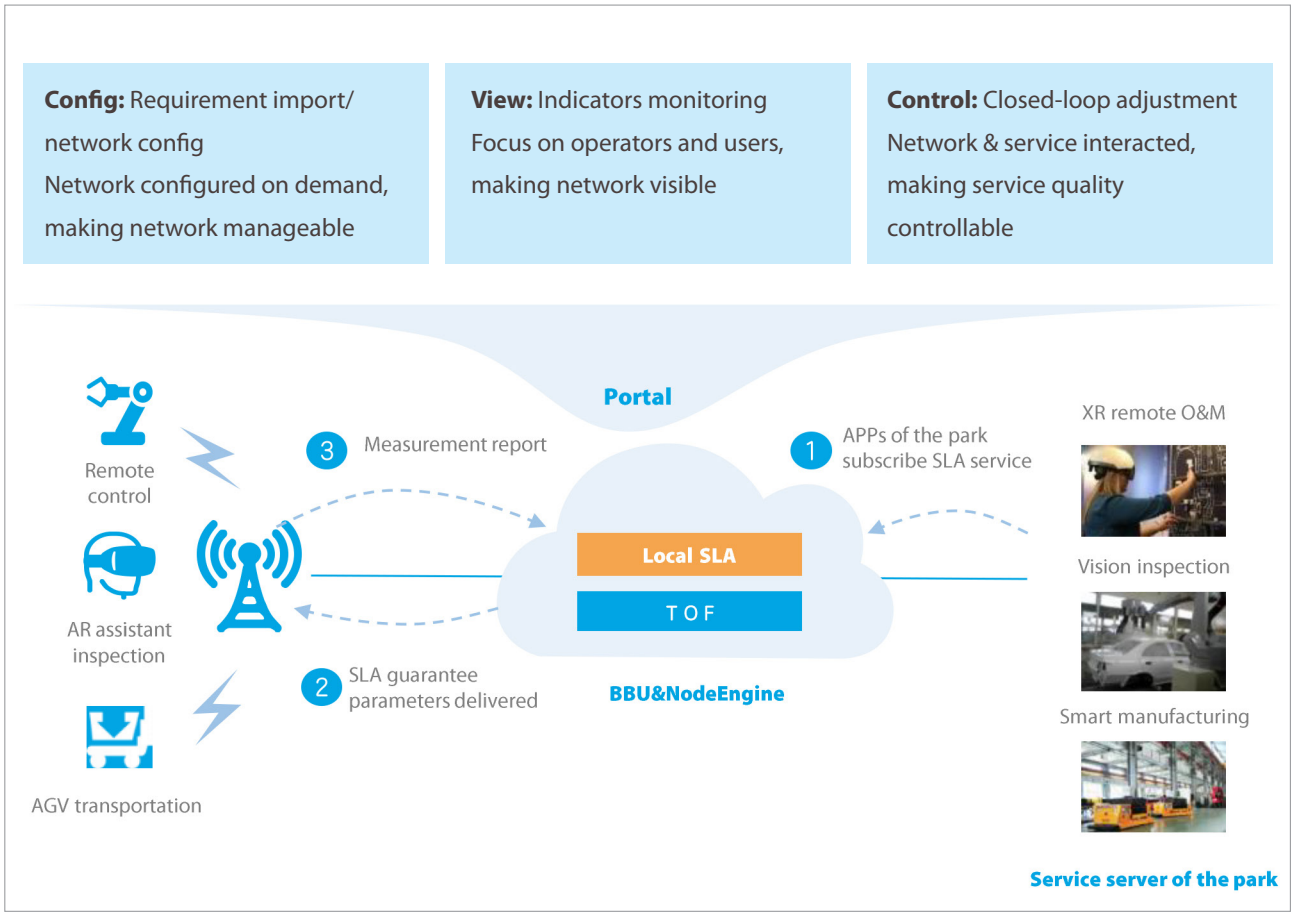


Figure 4-15 Open local SLA strategy

Open service capability, expansion on demand

Open positioning capability

Many service scenarios in industrial parks have strong requirements for indoor and outdoor positioning, such as cloud robots, AGV positioning navigation, positioning monitoring of personnel in production areas, and positioning and monitoring of important

assets. Through the integration of 5G networks and traditional positioning technologies, high-precision indoor and outdoor positioning can be achieved to meet the positioning requirements in industrial parks.

The 5G network is integrated with Bluetooth Low Energy (BLE) and Ultra Wide Band (UWB) to open the cascading power supply capability of the 5G intelligent indoor distribution system. The cascading of non-3GPP positioning equipment forms the integrated deployment mode of 5G small BS and positioning BS, and provides wireless communication and high-precision positioning capability, which can greatly reduce the deployment and maintenance costs.

The NodeEngine provides the Location Based Service (LBS) indoor location service, and integrates multiple location technologies to encapsulate the location capability as a unified external capability. Through the Local API gateway of NodeEngine, the location capability is open to third-party location applications in the industry. Through the LBS indoor location service provided by NodeEngine, the third-party location application provides the map presentation, track navigation, electronic fence and asset management services, and various location services for users.

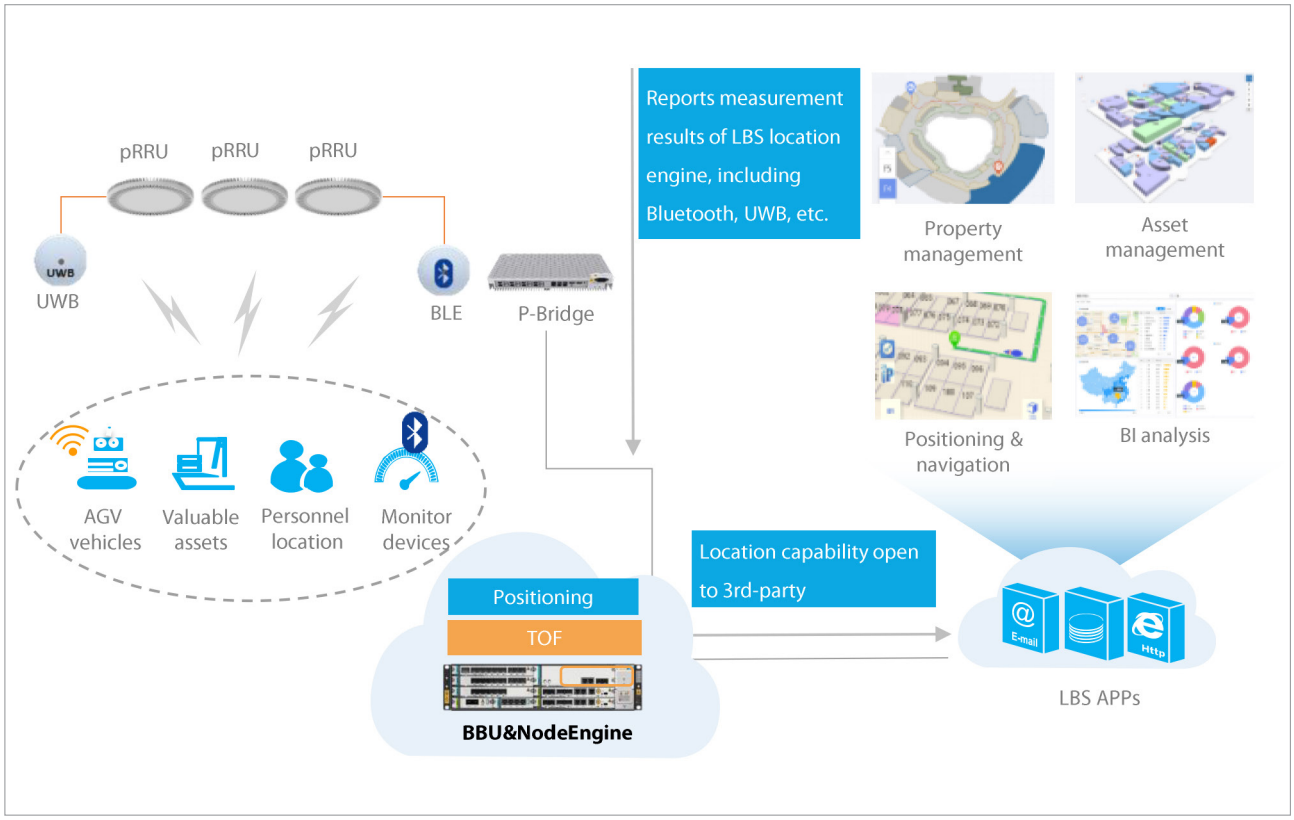


Figure 4-16 Open positioning capability

Industry cases empowered by NodeEngine

ZTE provides a one-stop intelligent and simple private network solution based on NodeEngine. It has been widely used in industrial parks, smart coal mines, smart social welfares, and smart stadiums to facilitate digital transformation of the industry.

Delicacy private network for industrial parks

Case Summary

In order to make the 5G technology better serve the manufacturing enterprises and provide the enterprise customers with flexible and fast local industry private network solutions, ZTE, Zhejiang Mobile and XinfengMing Group jointly created the "5G smart and simple one-stop local network" project. By deploying the NodeEngine solution, ZTE upgraded the 5G manufacturing platform and accelerates its comprehensive digital transformation process.

Service Scenario and Solution Value

In the 5G network of XinfengMing Group, most of the services are dedicated to their 5G production equipment. For example, AGV trolleys, visual detection equipment, and automatic assembly equipment provide 5G private network capability for XinfengMing by reserving slices and local offloading through PRB resources. This ensures that the access of such equipment and the unloading of local traffic are clearly separated from that of the users of B2C and B2B, thus guaranteeing the access and network performance of different types of terminals. Compared with other existing solutions, the end-to-end delay is shortened by 20%.

In addition, the NodeEngine solution provides the local self-service portal exclusive to the enterprise. The network configuration can be dynamically adjusted according to the application requirements, and the service quality can be viewed in real time to achieve flexible management and control. At the same time, the NodeEngine solution implements streamline EdgeQoS management and control of services. On one hand, the QoS requirements of local services are intelligently identified and distributed through edge AI to trigger network adjustment parameters to match service requirements. On the other hand, according to the service model, the resources required by dynamic scheduling are matched and guaranteed by bandwidth, latency, and reliability, thus achieving differentiated network services between local services. Through the streamline management and control of EdgeQoS, "network and service interaction" is achieved, and the perception of private network services and the efficiency of network resources are greatly improved.

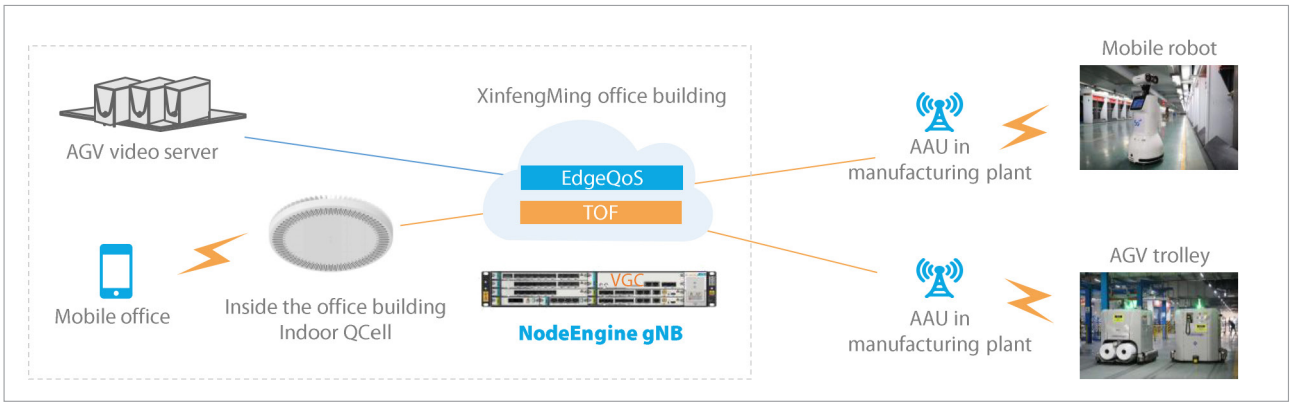


Figure 5-1 Jiaxing Fengming Park serves enterprise customers and dedicated to the delicacy service of private network

Intelligent coal mine, ensuring continuous service underground

Case Summary

ZTE, together with China Unicom Shandong Branch and BDS, completed the test and verification of the first 5G local offloading application in the coal industry in China. China Unicom Shandong Branch provided the dedicated 5G network in the coal industry, BDS provided the coal service test scenario, and ZTE provided the NodeEngine solution.

Service Scenario and Solution Value

Taken "underground private network coverage" of Yanshan Mining Co., Ltd as the target test scenario, the project uses 5G+NodeEngine BS-level local offloading to provide local private network services for Yanshan Mining Co., Ltd., meeting the requirements of data transmission security and local nearest access. The local smart shunting and eBridge local

interworking bidirectional access functions of ToF have been fully verified. The working-plane video monitoring data is sent to the underground integrated control center directly through ToF to reduce the delay by over 50%. The strategy of keeping the air-interface link disconnected and alive ensures that the core production services are not affected when the optical fiber between the underground and the ground is disconnected. Through eBridge two-way access to remote control and production equipment, the CPE dynamic IP address can be mapped into a fixed IP address to implement two-way interaction and meet the requirements of remote control and equipment management.

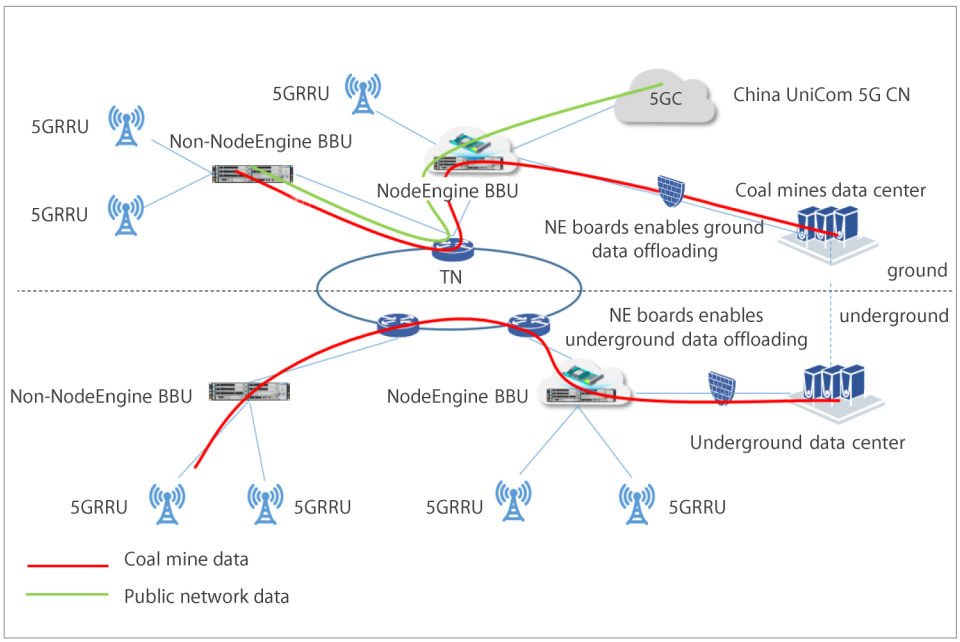


Figure 5-2 Shanneng Group NodeEngine private network solution provides local private network application for the services under the mine

Intelligent social welfares, smart local network for hospitals

Case Summary

Together with Quzhou Telecom and Quzhou People's Hospital, based on the customized 5G network solution of China Telecom, ZTE deployed the NodeEngine solution in Quzhou People's Hospital. In this scenario, the local intelligent service shunting of the BTS is completed, and the UPF links under the "ZhiYuan Mode" compose dual-link test of the medical service, and the NodeEngine intelligent and simple local network is built. It serves 5G customized network as a supplement to the "ZhiYuan Mode", and satisfies the requirements of the 5G ToB service scenario.

Service Scenario and Solution Value

The NodeEngine project is based on the 5G network to achieve wireless access of the mobile ward-round vehicle in the hospital. Through the intelligent and simplified local offloading of the BS, the ward-round vehicle can access the local network of the hospital, thus saving the time delay in viewing images. In addition, by combining with the customized 5G network solution of China Telecom, the dual-link service scenario of house query vehicle is achieved. Within the coverage of the BS in the hospital area, access the intranet of the hospital through NodeEngine. In the coverage of the BS outside the hospital area, access the intranet through the "ZhiYuan Mode" of 5G customized network. As a supplement, NodeEngine "forms the medical private network solution.

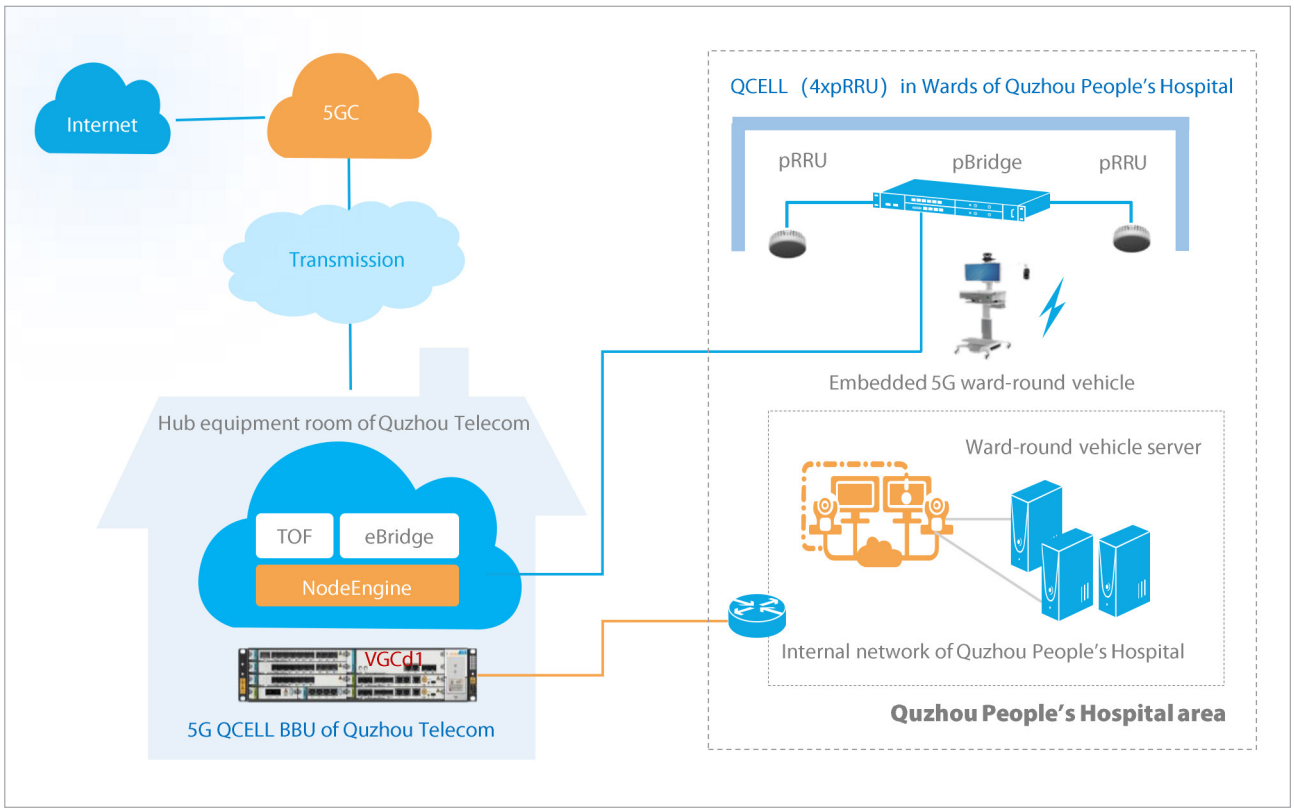


Figure 5-3 NodeEngine project of Quzhou Telecom People's Hospital, builds a medical network under the "ZhiYuan Mode"

Intelligent stadium brand new services for Sky Limit Entertainment

Case Summary

Together with Beijing Mobile and Sky Limit Entertainment, ZTE provides new XR service experience for venues. With the 5G large bandwidth + low latency capability combined with the NodeEngine local traffic offloading and eBridge functions, the multi-person real-time XR+ service is achieved.

Service Scenario and Solution Value

This project verifies the NodeEngine solution based on the real environment of the existing network, completes the service functions of BTS offloading and EdgeQoS, and passes the test and verification. At the same time, VxLAN/NAT-based VR service scenario, NAT-based 40Mbps-based V2V service experience, with RTT delay within 100 ms. In addition, based on the VR service model, the 5QI 80-based high bandwidth and low latency service can be provided on the basis of the initial subscription 5QI 6 of the ToB card to implement the APP-level 5QI service. Moreover, in the process of 4-channel VR service experience, the self-service portal can provide 5QI 80-based guarantee of large bandwidth and low latency service and KPI display, to realize real-time display of VR service quality.

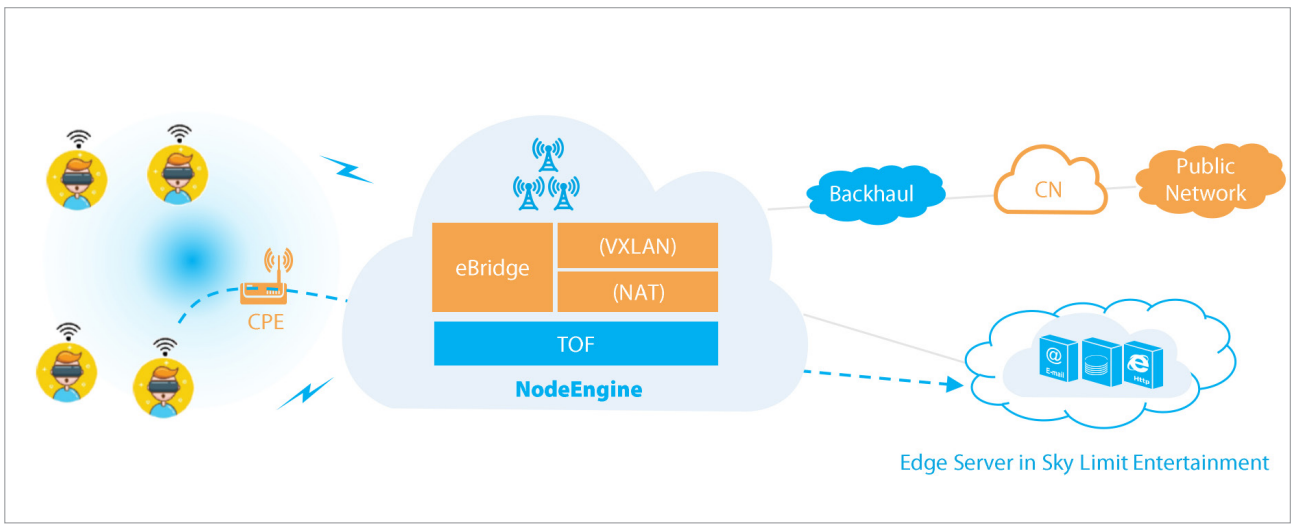


Figure 5-4 Multi-Person VR Service in Beijing Mobile's Commercial Network

Challenges and prospects

New infrastructure concept has facilitated China's great progress in 5G development. The latest statistics of Ministry of Industry and Information Technology (MIIT) shows that, up to now, the number of domestic 5G base stations has exceeded the megabytes, and the domestic 5G subscribers have also accounted for over 80% of the global total.

The booming 5G construction scale and the strong support of national policies lay a good foundation for 5G industry's development. It should be noted that the five "core elements" – terminal, network, cloud, edge computation, and services, are indispensable for 5G to truly serve the vertical industry and the end customer. At present, the ToB development still faces many challenges. For example, there is still a huge gap between the terminal chip, module capability, and cost and the industry terminal requirements. The enterprise network's requirements for low latency, high reliability and high security local applications conflict with the current public network WAN architecture of the ToC. The rigid demand for industry services and the best-effort supply capability service mode of the ToC network still need to be modulated. The gap between the OT/IT/CT fields needs to be filled up. The 5G+ industry needs to break the barrier and explore boldly with the vision of development and the courage of change. Guided by the value requirements of industry customers, based on the premise that the business model principles are feasible, ZTE will continue to innovate in the existing 5G private network solutions.

The 5G industry private network is designed to provide industry enterprises with a low-cost, high-value, manageable and controllable network solution. Low costs require that solutions should be simplified, that is, to give full play to the value of the public network, integrate the requirements of large networks and private networks, and make innovations in network architecture and technical solutions. High-value solutions need to have intelligent features, and can fully integrate service features with network capabilities, algorithms, and performance measurement, so as to bring the value of precision networks into play. Manageability requires an open solution to ensure seamless interconnection and integration between 5G networks and existing industrial service systems.

Entering the second half, the collision and integration of various cross-industry technologies will become the main stage of innovative solutions for 5G development. The integration of cloud computing, AI, digital twin, block chain, and computing power network-related new technologies with traditional BSs forms a powerful link between "innovation" and "tradition," and creates an upgraded version of intelligent BSs with NodeEngine as the core. It plays a greater role in developing new infrastructure, nurturing new kinetic energy and building new converged cloud network infrastructure.

Abbreviation

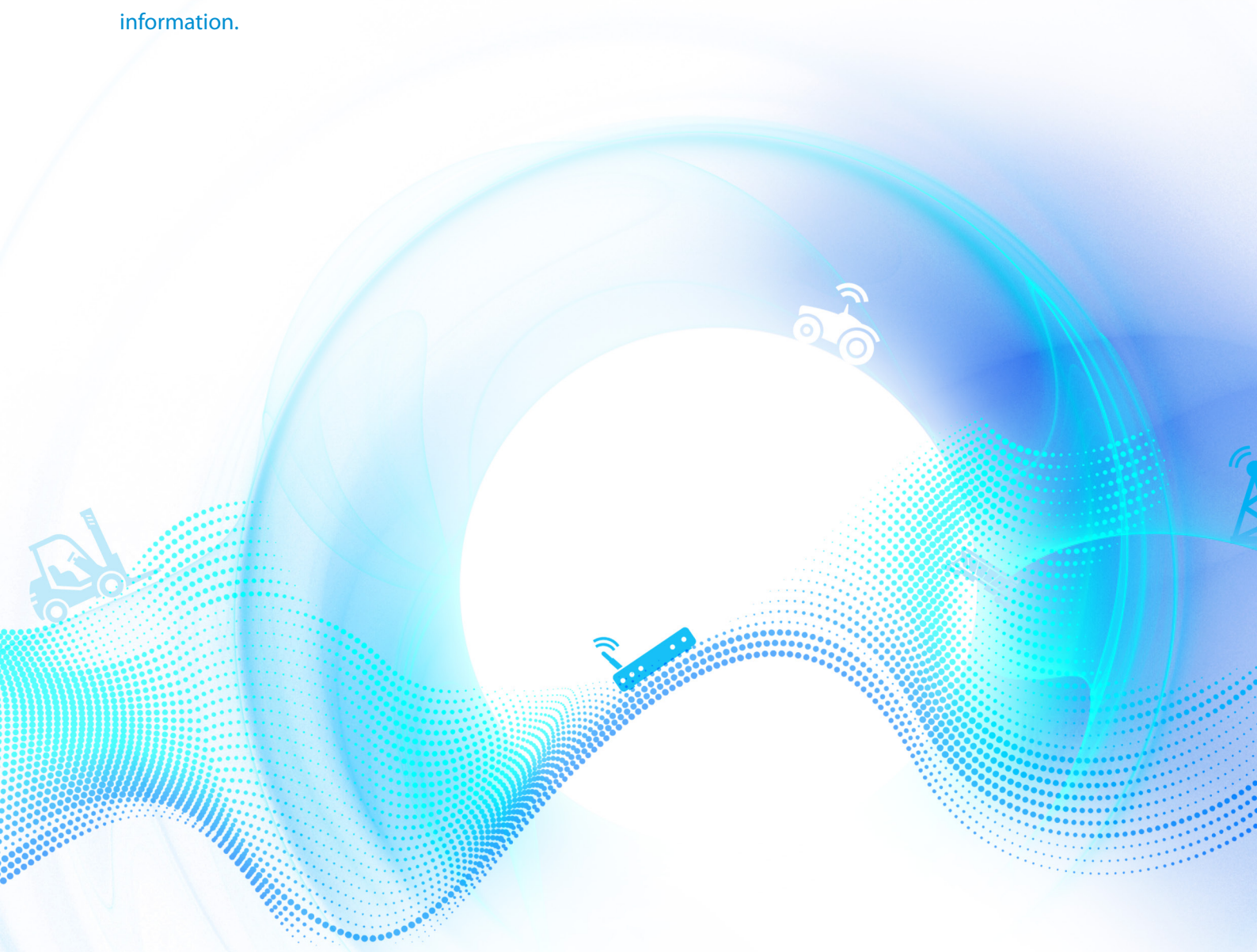
Abbreviation	Full Name
3GPP	3rd Generation Partnership Project
5GC	5G Core
5QI	5G QoS Identifier
App	Application
AGV	Automated Guided Vehicle
AI	Artificial Intelligence
AIE	AI engine
API	Application Programming Interface
AR	Augmented Reality
BBU	BaseBand Unit
BLE	Bluetooth Low Energy
CPE	Customer Premise Equipment
DPI	Deep Packet Inspection
DNS	Domain Name System
E-CID	Enhanced Cell-ID
IPI	Intelligent Packet Inspection
LBS	Location Based Service
NSA	non-standalone
NAT	Network Address Translation

Abbreviation

Abbreviation	Full Name
PRB	Physical Resource Block
PLMN	Public Land Mobile Network
QoS	Quality of Service
RRM	Radio Resource Management
RTT	Round Trip Time
SLA	Service Level Agreement
SA	standalone
SIM	Subscriber Identity Module
ToB	To business
ToC	To Consumer
TOF	Traffic Offloading
UWB	Ultra Wide Band
UTDOA	Uplink Time Difference of Arrival
UPF	User Plane Function
UE	User Equipment
VxLAN	Virtual Extensible Local Area Network
V2V	Virtual to Virtual
XR	Extended Reality

ZTE Corporation. All rights reserved.

The copyright of this document is jointly owned by the joint release unit. Without permission, no unit or individual shall use or disclose this document or any pictures, tables, data, or other information contained in this document. The information in this document will be continuously updated with the development of ZTE Corporation products and technologies. ZTE Corporation will not notify the update of such information.



ZTE ZTE CORPORATION

NO.55, Hi-tech Road South, ShenZhen,P.R. China Postcode:518057
Website:www.zte.com.cn Tel:+86-755-26770000 Fax:+86-755-26771999