GTI Research Report on 5G Industry Access Gateway

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Industry Access Gateway

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Content

Preface

The world economy has entered the information age. It has become the consensus of all countries to speed up the construction of informationization and networking. Besides providing public service carrier cellular network, network informatization also includes industry networks that offer customized solutions for various industry applications. The traditional industry network access adopts an analog system and cluster communication mode. With the progress of science, industry user demands gradually transfer from voice service, short message service, to image/video transmission, which belongs to broadband data services. Therefore, broadband communication that can provide diversified services has vast potential for

future development.

5G network has the advantages and abilities of high rate, low latency, big connection, and slicing. Combining with industry network, 5G network can meet various vertical industries' customized needs and bring better user experience to industry customers. What's more, in the initial stage of 5G commercial usage, access gateway, which is low cost and fast deployment terminal access device, can be quickly applied and meet the industry's needs. In order to service China Mobile 5G development plan, this research report puts forward the concept of industry access gateway. The technical specifications of access gateway used in industry and enterprise are discussed. In addition, suggestions are given on the application mode and test content of access gateway in typical application scenarios of smart park, smart factory and smart port.

Chapter 1 Current Status of Industry Access Gateway Products

1.1. Development of Vertical Industry Network

The world economy has entered the information age. It has become the consensus of all countries to speed up the construction of informationization and networking. Besides providing public service carrier cellular network, network informatization also includes industry networks that offer customized solutions for various industry applications.

Unlike the public network, vertical industry private network serves network applications of specific industries, specific departments, and specific groups. Thus, vertical industry private network meets diverse communication needs. Most of its customers gather in the industry with high requirements for performance and safety. The degree of customization is relatively high. As shown in the following figure 1-1, at present, the main application areas focus on the urban government network, park, public security, highway, airport, port, and other industries. Among these industries, public security and transportation are the most important markets.

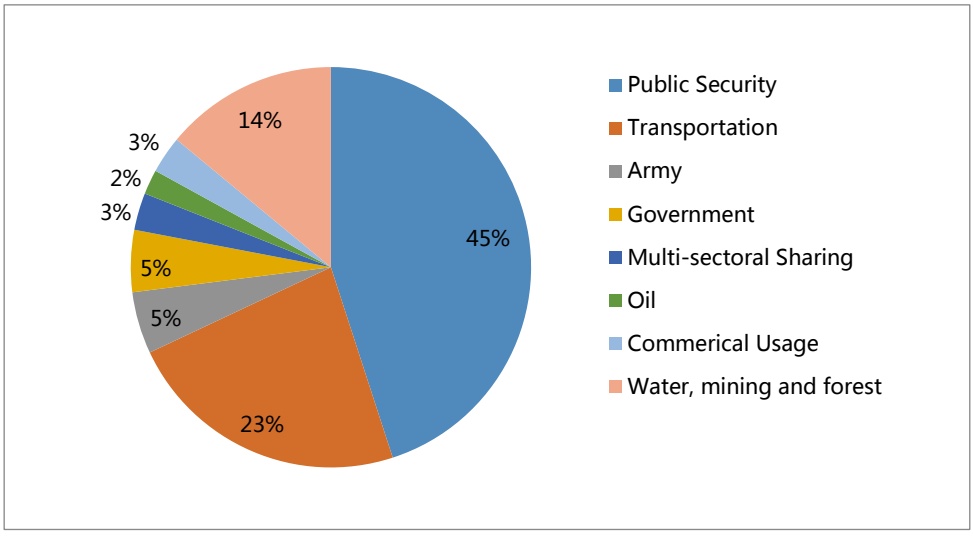


Figure 1-1. Distribution of global vertical industry customer fields

The global vertical-industry network services market is accelerating. Since 2015, the growth rate's size rose from 5% to 10%. It is expected to exceed 190 billion yuan by 2023. The country's emphasis on government and public safety and the increasing numbers of large-scale activities brought by China's rapid development benefit from the country's focus on government and public safety. The size of the market is also on the rise. As shown in Figure 1-2, combined with the historical data law of China's private network communication industry and the downstream demand growth rate,it is expected that the size of China's global vertical industry network service market will maintain a growth rate of about 15% in the future. The market size will reach 27.3 billion yuan by 2022.

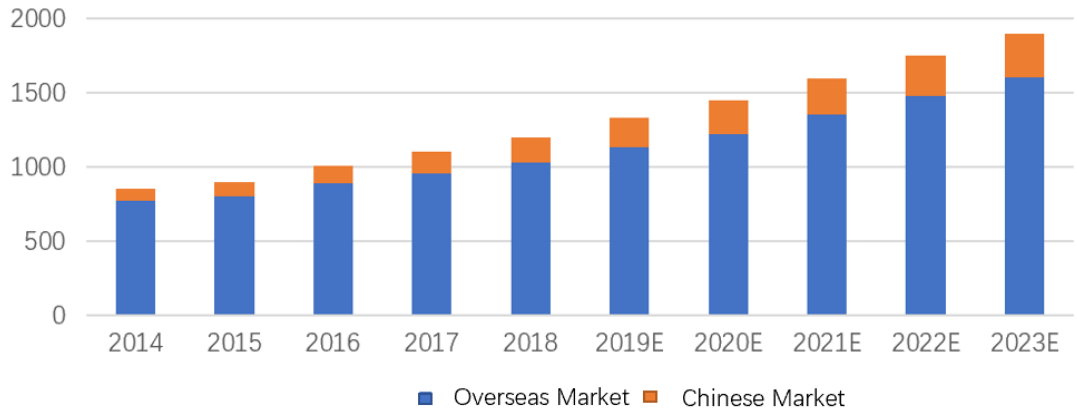


Figure 1-2. Global vertical industry network service market size (100 million RMB)

The traditional industry network access adopts an analog system and cluster communication mode. With the progress of science, industry user demands gradually transfer from voice service, short message service, to image/video transmission, which belongs to broadband data services. The traditional narrowband trunking private network system can only provide users with voice services and cannot meet

broadband data transmission needs. Therefore, broadband communication that can provide diversified services has vast potential for future development.

5G will be used commercially soon, and the communication also extends from the connection of people to the junction of things. Under this background, vertical industry applications are also pushed to the foreground, which has become a significant 5G application theme. The vertical industry network service has become an essential part of this topic because of its specificity and personalized service. Operators have advantages such as 5G high-bandwidth authorized spectrum and robust operation, and maintenance capabilities. They can provide high-quality 5G network services, meet the customized needs of various vertical industries, and bring better user experience industry customers. According to the predicting of SNS Research, infrastructure construction due to global LTE and 5G industry demand from 2018 to 2021 will bring a compound annual revenue growth rate of 30% for the communications industry. The market size will reach $5 billion in 2021.

1.2. Access Gateway Concept and Products

Gateway, as known as protocol converter, is used for interconnecting two different networks that have different high-level protocols. A gateway can be used for both LAN interconnection and WAN interconnection. In vertical industries, access gateways' extensive use provides network access capability for various sensors, such as industrial sensors that do not have or limit network access capabilities. Figure 1-3 shows the schematic diagram of the industry access gateway function. Therefore, to meet the development plan of China Mobile 5G, this research report divides the industry access gateway into two segmented application scenarios: industrial gateway and enterprise gateway.

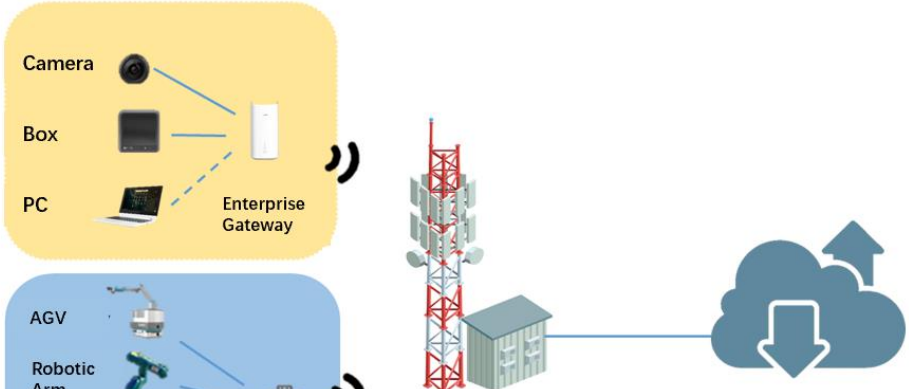


Figure 1-3. The schematic diagram of industry access gateway function

The following contents introduce the current industrial access gateway, enterprise access gateway product functions, and application scenarios.

1.2.1. Industrial Access Gateway

With the increasing need for automation, networking, and intelligent, together with the rapid development of communication technology, industrial customers' demand for industrial equipment networking is also growing from wired to wireless, from narrowband to broadband. All kinds of industrial communication equipment also arise at the historical moment, such as a serial server, wireless serial port server, industrial Ethernet switch, industrial Modem, industrial router, industrial cellular gateway (DTU), industrial intelligent gateway. This industrial communication equipment can well meet all kinds of industrial customers in different industries and different application scenarios, so to solve practical problems in industrial applications and realize the needs of upgrading and upgrading industrial equipment. The three most common types of cellular industrial communication equipment on the market are industrial DTU,

industrial router, and industrial intelligent gateway.

Industrial DTU, a serial port data transmission terminal unit, is used to convert RS-232/485 Serial port data to IP network data or convert IP network data to serial port data. Industrial DTU is a wired network Wireless terminal equipment for transmission over a wireless communication network. DTU can support wired or 2G/3G/4G cellular wireless networks. Using Cellular wireless DTU equipment does not require wiring settings. Thus, it only needs to pay a certain amount of carrier traffic cost to achieve remote data transmission quickly without maintaining the network. In many practical industrial or industrial applications, industrial DTU has been widely promoted and applied. Figure 1-4 shows its networking diagram.

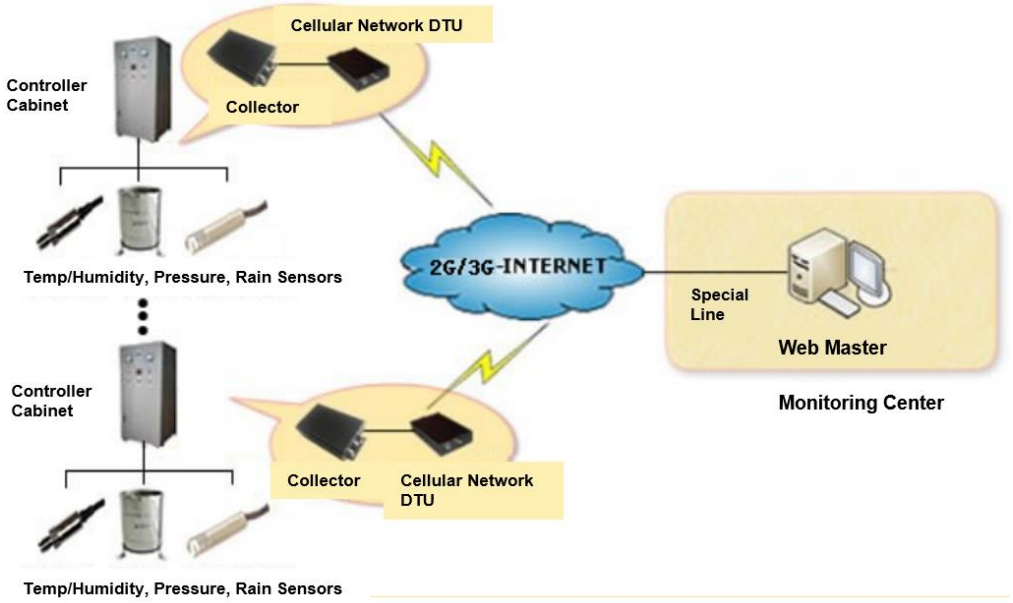


Figure 1-4. The schematic diagram of DTU networking

The acquisition of traditional equipment data is accomplished using an instrument, meter, or particular industry terminal with an RS232/485/422 data interface. However, traditional customers are not good at communication. It becomes a problem to leverage existing interfaces to achieve networking, realize data communication, implement remote data transmission and centralized management to meet customer requirements. DTU is the right key to help customers solve this problem. DTU mostly used for equipment dispersion, wiring inconvenience, unattended applications, such as remote collection of water electricity and heat meters, meteorological data collection, environmental protection, hydrogeology data remote collection, disaster warning, remote street lamp monitoring, oil well remote monitoring, vehicle-mounted monitoring, extensive equipment networking, new energy equipment networking monitoring and other fields.

The common forms of DTU are divided into two categories: shelled and embedded. The shelled one is usually installed in the electric cabinet, used for industrial application projects. The embedded one has a smaller size, and the interface is more accessible for customers to integrate and embed into users' devices. The shape of DTU products is shown in Figure 1-5.

DB9 shelled standard interface	Shelled - terminal row	Embedded -terminal row	Embedded - rows of pinholes

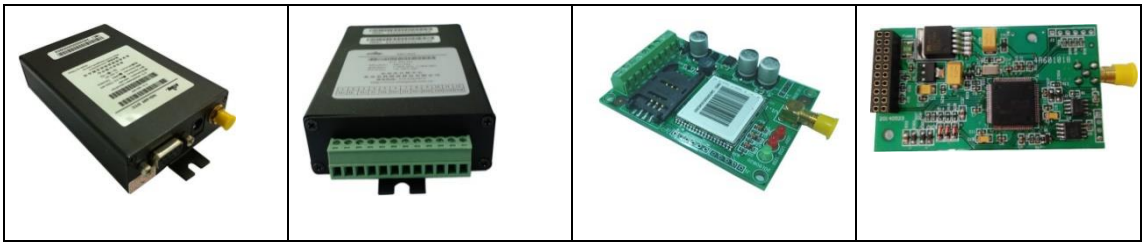


Figure 1-5. Configuration diagram of industrial DTU equipment

An industrial router is a router with industrial-grade characteristics. The usage occasions and application environments are industrial and industrial application sites. Different environments require continuous and stable industrial routers' work under relatively harsh environments such as electromagnetic interference, high /low temperature, high humidity, and high heat rank. The industrial wireless router adopts a high-performance industrial-grade communication processor and takes an embedded real-time operating system as a software support platform. The system integrates a whole series of communication protocols from the logical link layer to the application layer. It supports static and dynamic routing, PPP server and PPP client, VPN (including and IPSEC), DHCP server and DHCP client, DDNS, Firewall, NAT, DMZ host function to provide users with a secure, high-speed, stable and reliable, various protocols routing forward wireless routing network. Industrial routers support 4 G/ 3 G/ 2 G wireless network, cable, or Wi-Fi. One end of the router can be connected with industrial field IPC, industrial computer, camera, and other devices with an Ethernet interface. The other end can realize the WAN connection to implement remote transmission of device data.

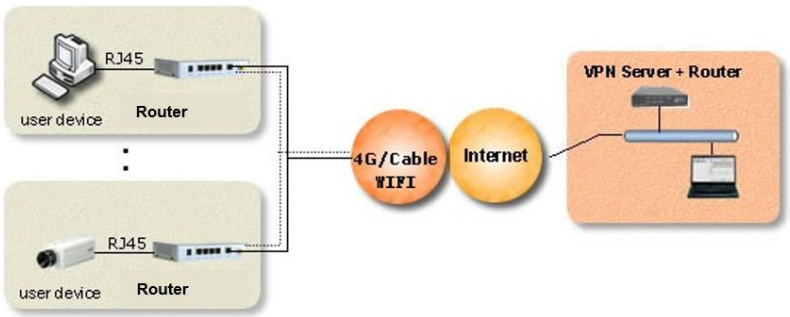


Figure 1-6. The schematic diagram of industrial router networking

The current industrial router has been used in all kinds of Internet applications, such as smart grid, smart transportation, smart home, financial IoT wireless router, self-service terminals connected to the Internet, industrial automation, intelligent buildings, fire control, public security, environmental protection, meteorology, digital medical treatment, remote sensing survey, agriculture, forestry, water, coal, petrochemical, and other fields. At present, widely used industrial routers can be divided into single network port, multiple network port, single card, single standby, and double card backup rank, For details, please refer to the following figure：

Single card single port	Single card multi-port	Double card multi-port
		

Figure 1-7. Configuration diagram of industrial router equipment

The emergence of industrial intelligent gateway solves complex and diversified industrial data transmission. Compared with DTU and router, which have been widely used, the industrial intelligent gateway appears more in industrial manufacturing applications to implement industrial manufacturing automation and intelligence in the factory and realize remote operation and maintenance of equipment outside the factory. Besides the data transmission and communication function of DTU and router, the industrial intelligent gateway also has the industrial data protocol conversion, storage, and other capabilities. An industrial gateway with various interfaces, protocol processing and transformation, data storage, and other functions is now more popularly known as "Internet of Things gateway." As a new term, in the future era of the IoT gateway, an IoT gateway will become a link between the perception network

and the traditional communication network and play a significant role. The IoT gateway can implement the protocol conversion between the sensing network and communication network and between different sensing networks and realize wide-area interconnection as an industrial gateway device. Local area interconnections can also be achieved. Besides, the IoT gateway also needs to have the device management function. Through the gateway of the Internet of Things, operators can manage the underlying perception nodes, understand each node's

relevant information and realize remote control.

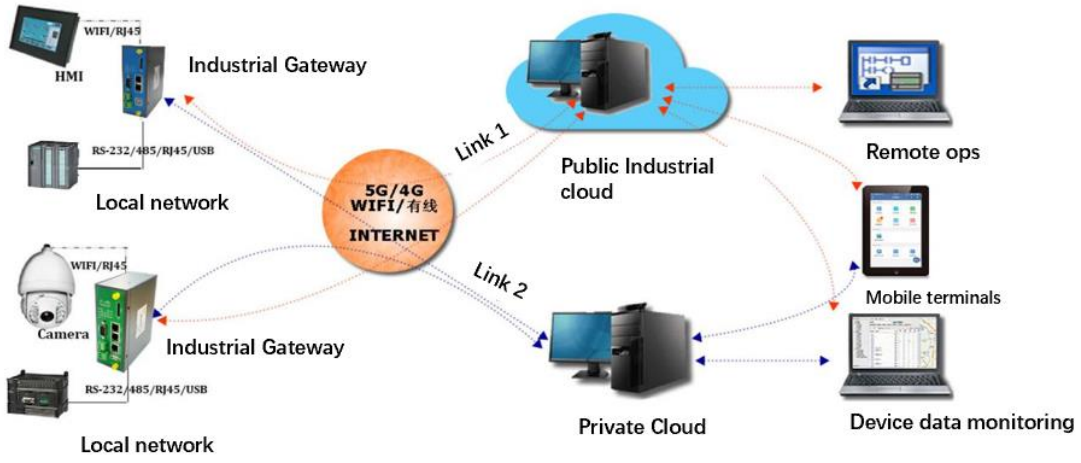


Figure 1-8. Industrial intelligent Gateway application diagram

The industrial intelligent gateway integrates various industrial data interfaces, including RS-232/485 serial port, RJ-45 Ethernet interface, USB interface, CAN, and other industrial bus interfaces. The industrial intelligent gateway's data interfaces are more abundant and can be connected with various industrial devices. It has also wired, WIFI, 4G, and other communication methods to realize data's local and remote communication. The industrial intelligent gateway has more powerful data processing and computing capability, which requires the analysis and conversion of industrial equipment data with different protocols and historical data storage to complete the compatible communication between different industrial equipment. Besides, due to

the rise of "cloud services," the industrial intelligent gateway also needs to have a common communication protocol interface such as HTTP \MQTT to dock with "cloud" services and fulfill industrial customers' demand for "cloud" data. Because of the need to be in the electric cabinet, consider the characteristics of easy installation and space-saving, the common industrial intelligent gateway adopts the installation's vertical method. The number and types of industrial intelligent gateway products are different. The choice of communication methods is different, and the size is also different. The primary product forms are shown in Figure 1-9.

Figure 1-9. The shape diagram of an industrial intelligent gateway device

1.2.2. Enterprise Access Gateway

Enterprise access gateway, which is the portal for enterprise users to access the operator network, realize enterprise internal equipment communication and the communication between internal equipment and external equipment communication. Compared to the AP+AC way of enterprise Wi-Fi network access plan, enterprise access gateway which has a plan of “Light cat+ routing+ voice+ TV set-top box+ TV set-top box” has obvious advantages in the information service market of SMEs, which accounts for 99% of the total number of Chinese enterprises. The enterprise access gateway can provide broadband to servicees, Wi-Fi, mobile communication, security, voice, IT outsourcing, and so on. Its networking diagram is shown in Figure

1-10 below.

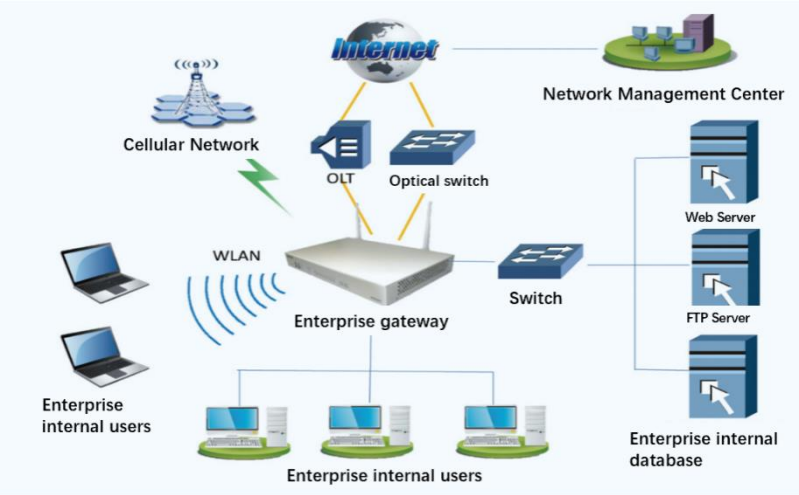


Figure 1-10. Schematic diagram of enterprise Gateway networking

Enterprise gateways have three different product forms according to the field of use：

- Access gateway for commercial entertainment mainly meets the hotel, dormitory, and other scenes of the Internet, TV, and entertainment function requirements. The device has an HDMI interface and supports set-top box functions, GPON, LAN/WAN, WLAN function. The device configuration is shown in Figure 1-11 below.

Figure 1-11. Access gateway configuration diagram for commercial entertainment

- Access gateway for stores and shops mainly meets the demand for network coverage and voice access for cost-sensitive enterprise scenarios. The access gateway supports GPON, LAN/WAN, WLAN, POTS function. The device configuration is shown in Figure 1-12 below.

Figure 1-12. Access gateway configuration diagram for stores and stores

- Access gateway for commercial building and the industrial park supports GPON, LAN/WAN, WLAN, POTS function for the hardware, IP Sec, firewall, DPI, QoS, VPN software agreement. The safety of enterprise equipment can be well guaranteed. The device configuration is shown in Figure 1-13 below.

- 

Figure 1-13. Access gateway pattern diagram for commercial buildings and industrial parks

1.3. Current Pain Points of Industry Access Gateway

The development of various industry networks has been widely used in multiple production and working environments and solved most field problems. However, there are still some pain points that need to be solved under some special situations. These problems mainly come from the performance limitation of the current network itself and the complexity and diversification of particular industrial application scenarios, which are primarily reflected in the following points：

- Difficult deployment of cable network: cable network has a series of shortcomings in the deployment model, including the deployment of complex, deployment long cycle, and high cost of deployment, line maintenance difficulties, not to facilitate later expansion and adjustment of the network, temporary equipment deployment, etc. Thus, cable networks can achieve better network quality, but not on a large scale. In some complex scenarios, such as mines, mines, the feasibility of using wired networks is very small.

- Wi-Fi network interference and high delay: The factors that restrict the quality of Wi-Fi networks usually include Wi-Fi devices are easy to drop calls, wireless heterogeneous networks interfere with each other, and the number of traditional Wi-Fi connections is small. Moreover, due to the channel competition mechanism, the Wi-Fi delay is high, not suitable for vertical industries with high delay requirements.

- 2 G / 3 G / 4 G network bandwidth and bad real-time performance : wireless cellular technology exist some occasions rate is not high, large time delay rank, in the industrial application of real-time control, high-definition video image transmission which has a higher request for wireless communication bandwidth and delays the scene is challenging to meet the requirements of its application. The industrial application scenario is more focused on the uplink bandwidth. LTE standard downward network theory is about 100-150 Mbps bandwidth (equivalent to 17 MB/s). However, the upside theory bandwidth is about 50 Mbps (6 MB/s), and generally measured uplink bandwidth is about less than 1 MB/s. This kind of speed does not apply to need high bandwidth industrial field applications, such as VR, high-definition video image transmission, and real-time data backup.

- Protocol conversion processing and customized problems: industrial field is very complicated because the industry needs to adapt to the market's need to produce diversified products. Simultaneously, industrial output development is a process of accumulation and escalation, which determines the industrial field is complicated and varied. Thus, the connection between the industrial equipment needs to edge to provide supercomputing ability. Currently, there exist more than dozens of different equipment, communication protocols in industrial sites. Understanding these protocols and network communication protocol to realize all kinds of standard connectivity problems and the heterogeneous network deployment and configuration, network management, and maintenance issues.

All these pose a significant challenge to industrial gateway products.

Chapter 2 5G Industry Access Gateway’s New Functions

As the next-generation mobile communication technology, 5G is an essential part of the new generation information infrastructure in the future. Compared with 4G, it will further improve users' network experience and meet the application demand of the Internet of everything in the future. 5G technology defines three scenarios, which can support high-rate, large-bandwidth scenarios, and support high-density sensor acquisition and low time-delay and highly reliable transmission capacity, which can cover industrial application requirements scenarios. On the network side, 5G technology adds network slicing and local shunt technology, which can meet industry data security, reliability, and real-time requirements. Besides, many industrial applications have significant differences in network performance requirements, data security requirements, and reliability requirements. The traditional industry network is not only invested and constructed by users independently but also costs much money. The operation and maintenance task is massive, and there is a risk of fast obsoleteness. With the acceleration of the commercial usage of 5G technology and the rapid maturity of products applied in the industry, the industry network's operation and operation are separated. The users themselves are transferred to the operators. For industrial applications, various cooperation methods such as leasing agent construction and service leasing are supported to minimize enterprises' investment, construction, and operation management pressure.

Given different subdivisions and different demands, different access networks should be adopted to complete the specialized industry network construction. Therefore, this chapter analyzes the potential market value and the emerging need for access gateway in the 5G industry by combining specific scenarios and pain points it solves.

2.1. 5G Industry Access Gateway's Network and Equipment Management Capabilities

As a network convergence entrance for enterprises and industries, access gateway provides users with wired, wireless, monitoring, local routing, and other functions and supports various local network construction types. Simultaneously, as the unified entrance of enterprise network, 5G Access gateway also has the enterprise network security and QoS tasks of integrating security exit, network traffic scheduling, user online behavior management, office content audit, etc.

5G access gateway provides enterprise users with the uplink ability of a 5G wireless network. It eliminates the limitation of an enterprise network on the wired network, can realize the rapid construction of the enterprise network, and share the necessity of network line construction. For enterprise users who need wired networks as the main traffic load, the 5G access gateway can also act as a temporary link during wired link setup, significantly reducing the network's opening time. What's more, 5G air port can also serve as the link backup of the enterprise network, ensuring network connection in case of failure and improving its stability and reliability.

The fusion product of 5G access gateway and industrial terminals provides network access capability for all kinds of industrial terminals and sensors, eliminating the current situation of strong coupling between them and wired connection. Intelligent robots, automatic machine tools, and AGV transfer vehicles in the smart factory can connect to the industrial 5G network through wi-fi signals or buses associated with 5G access gateway, and complete the uploading of production line data, receiving of work instructions, and unified scheduling of equipment resources. Under these scenarios, the 5G access gateway mainly realizes the transformation of network protocol. The network environment is relatively closed so that network access can be realized through lightweight product design.

2.2. 5G Industry Access Gateway’s Broadband Transmission Capability

Due to the LTE network's bandwidth, access capacity, and reliability, cellular access gateway in various fields has not been implemented regularly. The characteristics of 5G like high reliable network performance, large bandwidth, and large capacity will make cellular wireless access network gateway is expected to usher in a multi-industry demand blowout.

A 5G access gateway will meet the demand for new media for high-definition video transmission. The video collected by the terminal can be transmitted to the data center or cloud platform in real-time through the encrypted tunnel. The coverage of urban public welfare hot spots will be substantially improved. Media broadcasting and user data operation based on public hot spots will focus significantly on the industry. With the development of HD audio and video feedback in security and smart parks, the 5G-based access gateway will solve the technical bottlenecks in bandwidth and reliability of existing LTE solutions and promote the rapid development of related industries. The mobile access feature of the 5G Access gateway enables the government and office mode to get rid of geographical restrictions. Staff can use it to access the enterprise network through VPN encrypted tunnel and carry out work anytime and anywhere. The combination of 5G access gateway and the Internet of Things can enable the existing monitoring system and signal light system to realize 5G data high-speed return and flexible traffic flow scheduling. It will also generate many product demands.

2.3. 5G Industry Access Gateway’s Edge Computing Capability

To break through the "last kilometer" of the industrial Internet, the tide of the global industry's digital transformation is brewing up, and a new wave of industrial reform is set off. This wave's salient feature integrates "things" into intelligent interconnection, triggering industrial services and service models' innovation and exerting a profound influence on the value chain, supply chain, and industrial ecology. However, the Internet of Things is a vast and complicated system with different industries and application scenarios. According to the third-party analysis agency statistics, by 2020, there will be more than 50 billion terminals and devices connected to the Internet. More than 50% of the future data will need to be analyzed, processed, and stored at the edge of the network. How to solve the connection and management of massive terminals and the real-time analysis and processing of massive data have become a practical problem to ensure the industry's digital transformation.

5G industry access gateway support various industrial protocol and interface, not only widely adapted to different scenarios, industry connection, but support edge computing functions, by the edge of the open cloud computing power and management structure, fast meet the edge of the intelligent data processing demands of different industries, power industries rapid innovation, improve production efficiency and quality, reduce operational costs, enhance the level of public services.

2.4. 5G Industry Access Gateway’s Critical Security Guarantee

5G industry access gateway is a new generation gateway that integrates 5G air port, providing link backup function for the gateway through 5G air port link. Before the

arrival of 5G, traditional industry access gateway has no reliable air port link available and is faced with disadvantages such as low network robustness and difficulty in recovery. And the construction of 5G network will provide safe and dependable for industry customers link backup choice, can in failure or network cable network fault quickly switch to 5G cellular network for network access, effectively reducing the industry network failure and broken network, wired and wireless complimentary way enhance the overall quality of the entire network and core competitiveness.

Chapter 3 5G Industry Access Gateway Technology Analysis

This chapter analyzes the indicators that 5G industrial access gateway and enterprise access gateway need to meet in terms of 5G network, hardware and reliability, data interface, software function, safety performance, and other aspects, and gives the corresponding indicators for reference.

3.1. Network Technology Analysis

3.1.1. Network Access Capability

- 5G Industry access gateway should support 5G/4G dual mode and the frequency bands listed in the following table.

List 3-1. 5G Industry access gateway supports working frequency bands

network mode	Working frequency band	Uplink (terminal transmit)	Downlink (terminal receive)
5G	n41	2496MHz-2690MHz	2496MHz-2690MHz

	n79	4400MHz-5000MHz	4400MHz-5000MHz
TD-LTE	Band 34	2010-2025MHz	2010-2025MHz
	Band 39	1880-1920MHz	1880-1920MHz
	Band 40	2300-2400MHz	2300-2400MHz
	Band 41	2496-2690MHz	2496-2690MHz
LTE FDD	Band 3	1710-1785MHz	1805-1880MHz
	Band 8	880-915MHz	925-960MHz

- 5G Industry access gateway should support the access and service capabilities in NSA model and SA model. NSA mode need support Option 3x, and SA model need support Option2. Besides, SA mode needs to support single carrier 100MHz Village bandwidth.
- The number of antennas and MIMO streams that 5G industry access gateways should support is shown in the table below.

List 3-2. 5G Industry access gateway support antenna and MIMO Flow number

Networking mode	antenna number	Maximum NUMBER of MIMO streams
SA	NR：Down 4, Up 2	NR：Down 4, Up 2
NSA	LTE：Down 2, Up 1 NR：Down 4, Up 1	LTE：Down 2, Up 1 NR： Down 4, Up 1

- 5G industry access gateway should support the terminal total transmission power optional support Power Class 2.

- 5G industrial router, 5G industrial intelligence gateway, and 5G the enterprise gateway should support dual-frequency WLAN. The working frequency band is 2.4GHz and 5GHz. The 2.4GHz Frequency band should be supported IEEE 802.11n, Compatible with IEEE802.11b/802.11g.5GHz Frequency band should be supported IEEE 802.11ac Protocol and compatible support IEEE 802.11n. Optional support IEEE 802.11ax.

- 5G industrial gateway optionally support GPS and BDS location function.

3.1.2. Service capability

- 5G peak user rate of industry access gateway should meet:

  When the user is in SA mode, using n41 frequency band, 5ms frame structure, DL/UL subframe ratio 7:1:2, bandwidth 100MHz, and 256QAM, the peak rate of downlink 4 flows is at least 1.5Gbps, and the peak rate of uplink 2 flows is at least 250Mbps; using n79 frequency band, 2.5ms single-cycle frame structure, DL/UL subframe ratio: 1D:3U, bandwidth 100MHz, 256QAM, the peak rate of downlink 4 flows is at least 700Mbps, and the peak rate of uplink 2 flows is at least 700Mbps; Using n79 frequency band, 2.5ms double-cycle frame structure, DL/UL subframe ratio: 7D:3U, bandwidth 100MHz, 256QAM, the peak rate of downlink 4 flows is at least 1.35Gbps, and the peak rate of uplink 2 flows is at least 350Mbps.

  When the user is in NSA mode, B3+ N41 frequency band combination is used, NR bandwidth 100MHz, DL/UL subframe ratio is 7:1:2, When LTE bandwidth was 20MHz, it reached four downstream NR streams, 256QAM, with a peak rate of 1.5GBPs, two downstream LTE streams, 256QAM, with a peak rate of 170Mbps,

112.5Mbps for upstream single stream, and 67.5mbps for LTE single stream.

- 5G enterprise access gateway optional support voice function, including those that support FXS voice, VOIP class.
- 5G industry access gateway should support sending SMS.
- 5G industry access gateway should satisfy the following delay requirement: SA mode, NR control surface idle state into a connected state delay within 100 ms, idle state or inactive state into a corresponding state time delay within 20 ms; NR user face end-to-end delay is within 10 ms with pre-scheduling and 15 ms without pre-scheduling.
- 5G industry access gateway should support hardware acceleration and software capabilities to realize the large bandwidth and data forwarding function, further acknowledging the edge of computing power. Hardware acceleration can be completed by the software running on the CPU with specific hardware. For example, ASIC, FPGA, or multi-core processor can be used as the device to realize the acceleration function. Software acceleration improves performance by optimizing software architecture and providing software acceleration frameworks, such as DPDK class.
- 5G industry access gateway should support section function, including slice-based on different service choose to access the corresponding network type, able to carry in the signaling message network slice identification (S - NSSAI) and passed to the network, support stored and updated network section related logo, and can simultaneously access multiple (same type section number greater than or equal to 2) network section.

3.2. Hardware Function Analysis

3.2.1. Hardware Specifications

- 5G industry access gateway size is calculated by length * width * height, with the most extended side length not exceeding 50cm and weight not exceeding 1.5kg.
- 5G industrial access gateway can adopt an "aluminum profile + front and rear panel." The upper and lower separate structure is compact, the assembly is convenient and efficient, and the equipment is easy to maintain. Horizontal desktop placement, wall-mounted installation, and rail-mounted installation should also be supported.
- 5G enterprise access gate is generally installed inside the metal box, such as the cabinet, so the antenna should be guided to the outside of the cabinet to obtain a stable network signal and support the built-in/external interface. For devices that do not have built-in antennas, the hardware interface requirements are as follows：

  Rf interfaces require external exposure 5~20mm；The indoor rf interface shall be SMA Male；The RF interface for outdoor type should be SMA Male /N type.
- 5G maximum power consumption should not be more than 30W when the access network switch is working normally, and a 220V AC power supply range should be supported. For 5G industrial access gateway, the following power supply modes should also be supported to apply to different industrial field environments：DC power supply support +12~+48V broad voltage input; PoE power supply is compatible with 802.3AF/AT standard PoE input.
- 5G industry access gateway can be used RICS (ARM, MIPS)or X86 CPU Platform. The primary frequency is suggested to be higher than 800MHz,

supporting more than 200MIPS.

- 5G Industry Access Gateway used RAM should be higher than 512M Byte, FLASH should be higher than 512M Byte.

- 5G industry access gateway supports one power and system status indicator, one 5G/4G module working status indicator light. To contain Wi-Fi and WAN/LAN, the functional gateway should also support at least 1 WI-FI running indicator light, 1 WAN status light, and 1 LAN status light. Cellular network signal quality indicator light is recommended.

- 5G industry access gateway should have one power key and one hardware reset button. The keystroke time is less than 3S, and the device shall reset the system. When the key-hold time is more than 3s, the device will resume factory settings. It also supports WPS and Wi-Fi button reuse, Wi-Fi function start or turn off within 3 seconds, and starting WPS function after 3 seconds.

3.2.2. Data Interface

- 5G industrial access gateway is equipped with at least 1 RS-232 DB9 port and 1 RS-485 wiring terminal row for data acquisition of lower PLC, CNC, or sensor through a serial port.

- 5G industrial router, 5G industrial intelligence gateway, and 5G enterprise access gateway must support one 100/1000 BASE-T Ethernet interface that complies with the IEEE 802.3-2005 provisions optionally support one GE the mouth of light.

- 5G enterprise access gateway optionally supports GPON/EPON interface. GPON interface should conform to '*China Mobile GPON Equipment specification*' requirements. The light module should be adopted Class B+. With the OLT cooperate to meet the Class C+ optical link power budget, optical interface parameters should conform to G.984.2 Amd1 and Amd2 relevant requirements.

EPON interface should conform to '*China Mobile GPON Equipment specification*' requirements. The light module should be adopted PX20+.

- 5G enterprise access gateway optionally supports POTS Interface. It should comply with the provisions of YD/T 1054-2000.
- 5G industrial access gateway supports at least 1 DI and 1 DO digital switch interface.
- 5G industry access gateway should support 2 SIM/USIM cardholders compatible with 3.3V/1.8V. Two SIM CARDS can be inserted simultaneously, and one SIM card can be used according to the configuration to realize the redundancy of the upper link and enhance the reliability of the network connection. The SIM/USIM interface should meet the requirements of '*China Mobile User Card Hardware Technical Specification*.' If the air writing card is supported, it should meet the ' *China Mobile Internet of Things Private Network Writing Card Technical Specification*.'
- 5G industry access gateway should support at least 1 USB Type-A interface conforming to 2.0 or above specifications.
- 5G industrial router and 5G industrial intelligence gateway should support 1 Micro SD interface to insert Micro SD card and expand flash to store local data.

3.3 Software Function Analysis

3.3.1. Control Function

- MQTT should support 5G industrial router, 5G industrial intelligence gateway, and 5G enterprise access gateway. Transparent, CoAP, HTTP, XMPP, SNMP, FTP are optionally supported. 5G industrial intelligence gateways must support Modbus protocol and support DNP3, SNMP, BacNet, ICE101, ICE104, DLMS, CANopen,

Siemens S7, Omron FINS, OPC-UA optionally.

- 5G industrial router, 5G industrial intelligence gateway, and 5G enterprise access gateway static routing should support RIP, OSPF, BGP routing functions, supporting IPsec/OpenVPN/GRE/L2TP/PPTP/DMVPN.

- 5G industrial intelligence gateway and 5G enterprise access gateway should support the capabilities of various priority services, mainly including traffic classification, priority labeling, queuing and scheduling, traffic shaping and traffic control, congestion avoidance, cache management.

- Support data flow classification, including according to the source IP (including the network segment), purpose IP(including the network segment), source port, destination port, physical interface (including SSID) perform flow classification ; support according to the source MAC address, purpose MAC address, 802.1p perform flow classification ; support according to DSCP perform flow classification ; support by protocol type (TCP/UDP/ICMP) perform flow classification.

- 5G industrial intelligence gateway and 5G enterprise access gateway should support using DSCP or 802.1p to priority marking for the above classification results and shall support the bandwidth guarantee and restriction mechanism based on data stream classification results.

- 5G industrial intelligence gateway and 5G enterprise access gateway should support speed limit for upstream and downstream data flow based on the user side physical port, VLAN, IP address (including the network segment) granularity of at least 512Kbps.

- 5G industrial intelligence gateway and 5G enterprise access gateway should

support at least four priority queues and map service flows to different queues based on the results of data flow classification.

3.3.2. Management

- 5G industrial intelligence gateway and 5G enterprise access gateway should support multiple management functions, including Web, CLI, SMS, and the equipment management platform realizes the remote management function of access gateway equipment. Remote management functions include logging, fault diagnosis, system configuration, alarm management, performance monitoring, API permissions class.

3.3.3. Upgrade

- 5G industrial intelligence gateway and 5G enterprise access gateway should support local, or Web, CLI, USB, SMS manage platform upgrade firmware with upgrade exception alarm. During the upgrade process, there are no abnormal situations such as crash or service failure. Fault tolerance protection will be carried out for downloading upgrade package, decompressing upgrade package, incremental upgrade, and full upgrade when the network is off, power is off, and the terminal can automatically resume normal working status.

3.4 Safety Function Analysis

3.4.1. Device Safety Function

- 5G industry access gateway should prevent DDoS attack function, prevent LAND, Ping of Death, SYN Flooding, ICMP Redirection, Smurf, and Winnuke these types of attack.

- 5G industry access gateway should provide an anti-port scanning function,

supporting to prevent malicious port scanning by other devices or applications.

- 5G industry access gateway should be configured to limit the number of source MAC addresses learned from each user's LAN port.
- 5G industry access gateway should support firewall functions, firewall level setting, firewall rules configuration, and message filtering based on the following rules: supporting message filtering based on source and destination MAC addresses; supporting message filtering based on source IP address and range segment, destination IP address and range segment; supporting packet filtering according to IP source port and range segment, destination port, and range segment; TCP/UDP/ICMP/TCP+UDP/ANY option is required for packet filtering according to the transport layer protocol type of IP packet. Supporting packet filtering based on the transport layer protocol type of Ethernet packet, requiring IP/PPPoE/ARP options; It supports the selection of processing mode for messages with matching rules. There are two processing modes for messages with matching rules: allow mode and disable mode, and the default mode is a disabled mode.
- 5G industry access gateway should support the multicast that prevents the user from doing the source and prohibit the IGMP Query and multicast data packets issued by the user port.
- 5G industry access gateway should support suppressing to protocol-specific broadcasting/multicast packets (for example: DHCP, ARP, IGMP rank) and can restrict the rate of other two-layer broadcast messages.
- 5G industry access gateways should avoid common web vulnerabilities such as SQL injection, XPath injection, file upload, directory traversal, and so on.
- 5G industrial router, 5G industrial intelligence gateway, and 5G enterprise access

gateway should guarantee remote management port security. By default, remote management protocols such as SSH and Telnet, including SSH and Telnet protocols for standard and non-standard ports, should be disabled for devices. If SSH and Telnet remote management protocols need to be opened under circumstances, the account password authentication measures that meet certain requirements should be set up, and no empty command or weak password login should occur.

- 5G industrial router, 5G industry intelligent gateway, and 5G enterprise access gateway should guarantee the serial port safety management, and be disabled by default gateway equipment serial ports, such as under the particular circumstances need to enable a serial port, The login password must be added and set the account password authentication measures to meet specific requirements. The device should not talk to or weak password to log in. The device should not have a back door in any form, such as a hidden back door, a secret channel, etc. For example, the administrator reserves an account unknown to the user, opening a remote management port unknown to the user, preset or reserving a login method unknown to the user, and so on.

3.4.2. Network Access Security

- 5G industrial router, 5G industrial intelligence gateway, and 5G enterprise access gateway should support the following access control functions: supporting the implementation of corresponding access control policies based on the parameters such as source/destination MAC address, source IP address, source port, destination IP address, destination port, transport layer protocol and time; Automatic or administrator binding of IP/MAC addresses should be supported; When access control conflicts with QoS, access control function takes precedence.

- 5G industrial router, 5G industrial intelligence gateway, and 5G enterprise Access Gateway should support the following content filtering functions: content filtering functions based on specific or wildcard-containing URLs should be supported; 5G router and gateway should provide for setting up black and white lists and implementing import and export operations.

- 5G industrial router, 5G industrial intelligence gateway, and 5G enterprise access gateway should support the following ARP attack prevention functions: the ARP broadcast storm suppression function should be supported, and the threshold value of broadcast message restriction can be set; The function of sending free ARP messages should be supported.

3.4.3. Voice Security

- 5G enterprise access network should support OPTION 60 carrying encrypted voice account authentication information function and cooperate with BRAS to realize the authentication of voice IP address DHCP application, to prevent illegal users from applying for voice IP address.

3.4.4. WLAN Security

- 5G industrial router, 5G industrial intelligence gateway, and 5G enterprise access gateway should support the following WLAN safety features: SSID broadcast on/off function, enabled by default; Supporting Open System and Share Key two link-layer authentication methods; Supporting 64bit, 128bit WEP encryption; The secret key Can be used HEX or ASCII character input ; should support WEP, WPA-PSK, WPA2-PSK model; Supporting AES, TKIP encryption; Two-layer isolation between wireless terminals connected under the same SSID should be supported; Global speed limits should be supported.

3.5 Performance Analysis

- 5G industrial access gateway can be divided into the outdoor type and indoor one according to the user location. The outdoor access gateway should meet the IP41 level defined in GB 4208. The indoor access gateway shall meet the IP30 class defined in GB 4208.

- 5G indoor type of industrial access gateway should typically operate under the conditions of ambient temperature -10℃~+50℃ and relative humidity between 10% and 95%. The outdoor type should typically work at an ambient temperature of -40℃~+55℃ and relative humidity of 0%~100%.

- 5G electromagnetic compatibility characteristics of industry access gateway should meet the requirements of YD/T 1965-2009 and GB17626.

- 5G industry access gateway product's design life is more than ten years ; Within the product life cycle, YRR and LTR should be smaller than 1% ; Life analysis of life-limited devices (for example, electrolytic capacitors) are required to ensure that product life requirements are met.

- 5G safety requirements for industry access gateway products should meet GB 4943-2011 '*Safety of Information Technology Equipment*.'

- The average trouble-free time of the 5G industry access gateway should be more than 100,000 hours.

Chapter 4 5G Industry Access Gateway Applications

This chapter introduces the application scheme of 5G in three typical application scenarios of smart park, smart factory and smart port, and shows the application of 5G industry access gateway in these application scenarios.

4.1. Smart Park

Park generally refers to unified planning and construction, water supply, electricity supply, gas supply, communication, road, warehouse, and other supporting facilities, layout reasonable and can meet the needs of building group engaged in particular industry production, including an industrial park, industrial park, logistics park, urban industrial park, science and technology park, creative park, etc. There is a strong demand for information transformation in the park. At present, the park mainly USES Wi-Fi as the mode of coverage, which has the disadvantages of weak network coverage and unable to realize seamless mobile switching of services. The introduction of 5G can provide more refined management means for the park, meet the needs of smart construction of the park, provide a high-speed and stable network environment, and provide the possibility for the integration of information technology and the service needs of the park.

The use of 5G to improve the park's security management can realize the introduction of 5G cameras for real-time monitoring, monitoring, and inspection of people, vehicles,

and equipment in the future. The network environment must meet the low cost of networking, convenient construction, no dead space for monitoring, high security, and high reliability.5G network's high bandwidth and low latency make it possible to have an unmanned mobile inspection. By installing 5G DTU into the robot, the robot can complete the collection of campus people, vehicles, equipment monitoring video data, real-time analysis, and processing, identify the personnel status, vehicle information, equipment running status, encounter emergency alarm in time, park intelligent monitoring management functions.

The existing park cloud office applications need big connection bandwidth access ability. The current campus network construction uses a wired network connection. Lines deploy workload big. Structure affects the regular operation and daily equipment compatibility problems, only need 5G enterprise access gateway deployment location in the center of the space, which can quickly deploy office network; Future of video conference equipment for data transmission bandwidth, time delay, and access number has high requirements will be 5G enterprise access gateway via USB 3.0 and HD camera connection, can quickly build real-time high-definition conference system, with the aid of edge computing, collaborative office, AR technology, 4 k / 8 k HD transmission capacity, promote the upgrading of office field, real-time HD meeting, office together.

Simultaneously, the park's production and office data have low requirements for security and confidentiality and are sensitive to cost. Therefore, it can be considered to share the existing 5G wireless air port with public network users to meet the current service demands.

The 5G networking scheme of the park is shown in Figure 4-1 below.

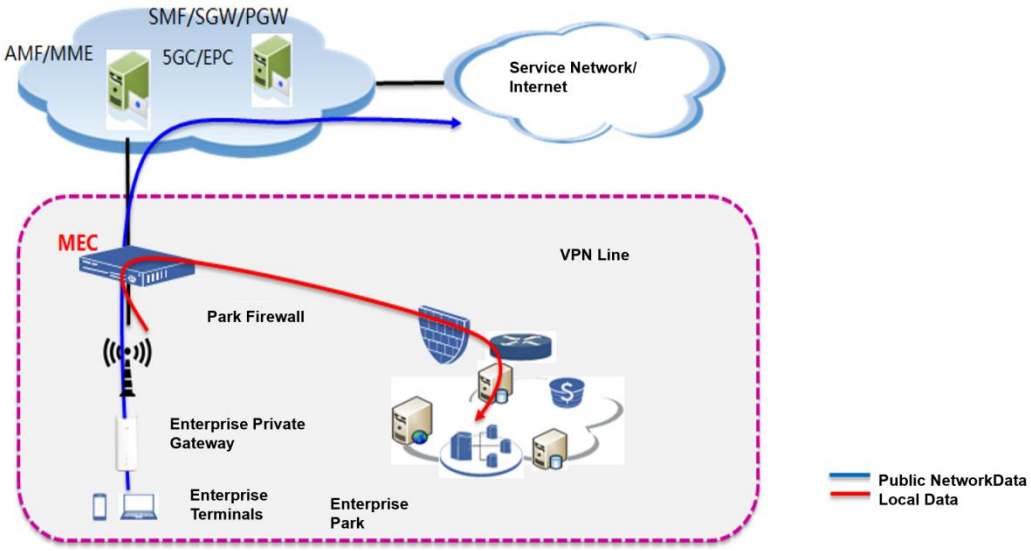


Figure 4-1. Networking plan diagram of 5G Park Network

The park network based on 5G has the following advantages：

- To reduce construction costs, the park's original network is mainly Wi-Fi and wired, of which Wi-Fi is a one-time investment, and operators are also required for maintenance. The reuse of a 5G network built by operators provides security for the park, effectively reducing network construction costs in the park.
- It solves the problem of poor user experience in the existing network, satisfies the service continuity in the park, and at the same time, the installation location of monitoring equipment is not affected by external factors.

In the smart park application scenario, the 5G industry access gateway plays a vital role because of its various voice interface and network interface, strong wireless coverage capability, security protection capability, and edge computing capability. Its main functions and functions are as follows：

- As high-performance terminal equipment of 5G network, it adopts the industry-leading 5G technology to convert 5G signals into WLAN signals and

network line access, providing wireless broadband access services for the park and enterprise users.

- Set "light cat + route + telephone access + TV set-top box + industry intelligent application" function in one.
- It integrates the functions of ONU, router, switch, firewall, edge computing service into one, and reduces the construction and maintenance cost automatically through work order, and makes the network flatter.
- Provide multiple gigabit LAN ports and multiple voice access, not only can access AP, monitoring, computer, multimedia terminals but provide a standby port, in the guarantee of broad bandwidth, to meet the premise of large traffic data transmission, and meet the future more data terminal access requirements.
- Support firewall, anti-attack, URL blacklist, and other security functions, can provide a safe and reliable Internet environment.
- It has strong edge computing capability, super-strong computing performance, large capacity storage, flexible configuration, small volume, a wide range of supporting temperature, strong environmental adaptability, easy to maintain, and manage.

4.2. Smart Factory

A smart factory is a new stage in the development of modern factory informatization. It is based on the digital factory and uses the technology and equipment monitoring technology of the IoTs to strengthen information management and services. 5G smart factory application involves industrial production, including raw material logistics, production control, product testing, plant environmental monitoring, plant asset management, etc. Different types of applications have differentiated isolation

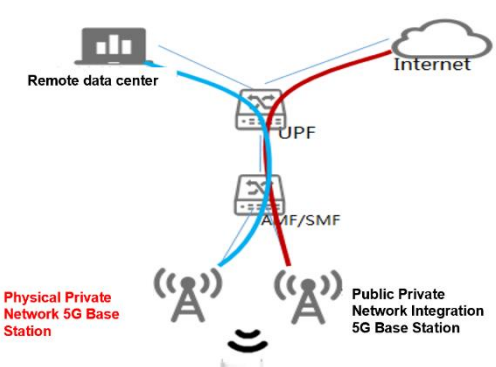
requirements for networks.

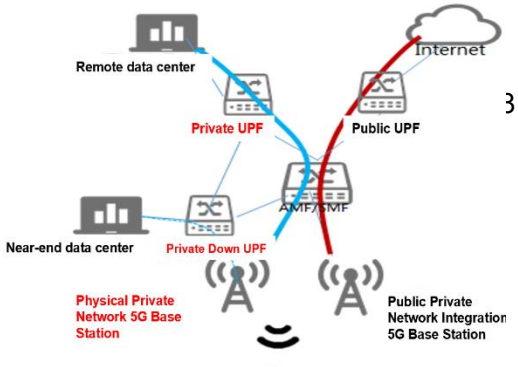
Typical smart factory 5G network architecture is shown in Figure 4-2, which can be divided into the following three architectures according to service performance and data security requirements :

- For a non-sensitive service such as office service and environmental monitoring in the factory, figure 4-2(a) network method can be adopted to realize data isolation by using core network slice to ensure network service performance, with fast deployment and the lowest cost. Meanwhile, the 5G access gateway is applied just like the smart park, providing signal coverage of office computers through a 5G enterprise access gateway radiating Wi-Fi signals.

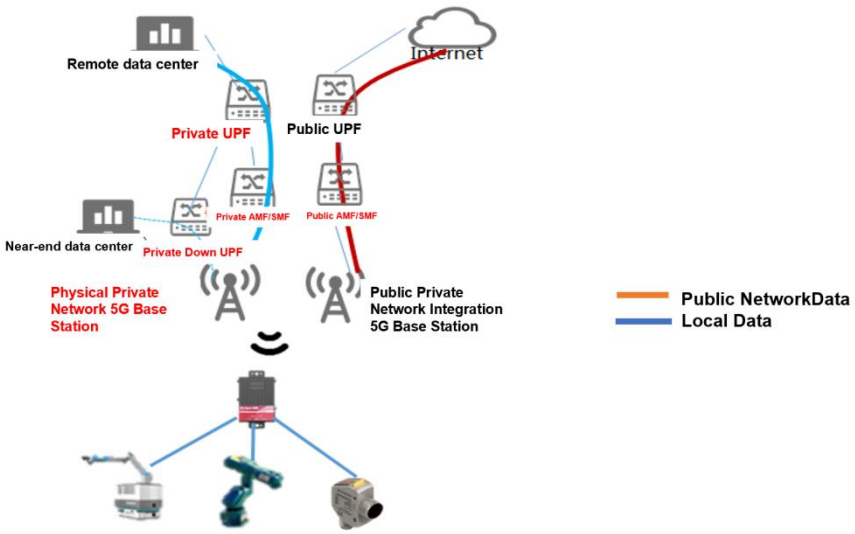
- For plant logistics, asset management service, data needs to be specific security, privacy protection, can consider using figure 4-2 (b) network architecture, the user plane carrying private data, ensure the data security, including for delay-sensitive service, also can use the user to reduce surface subsidence delay, at this point, 5G industrial access gateway can be used by cars, cameras, in the form of a USB connection device for data forwarding service.

- For a sensitive service such as production control and product detection in the factory, figure 4-2(c) network architecture can be considered. A unique core network can carry critical data to ensure complete physical isolation of data high data security and reliability. For delay-sensitive service, the user surface subsidence method can also be used to reduce the service delay. At this point, the 5G industrial access gateway needs to manage the production control equipment through the serial port or Ethernet and bear the function of industrial Fieldbus protocol conversion.





(a) Non-sensitive service (b) Logistics transportation, asset management service



(c) Sensitive service

Figure 4-2. 5G Network architecture of smart factory

Using 5G as an alternative or supplement to existing factory networks has the following advantages :

- The existing factory network is the coexistence of wired network and wireless network, industrial bus, industrial Ethernet, industrial wireless multiple transmission protocols aliasing to realize network interconnection and interworking. The network complexity is high. Communication is difficult. It is not easy to adapt to flexible manufacturing, high performance, and easy to expand the intelligent factory's needs. With 5G access network unified access, communication protocols can be unified, and all layers of industrial production can be interconnected.

- The construction of a high-quality network, relying on 5G authorization frequency and three scenarios support capability, 5G can provide the customized network for smart factories and provide customized network transmission solutions for applications with massive bandwidth, low latency, and high reliability. Simultaneously, relying on the local streaming and network slicing capability of 5G provides the factory with a highly secure and private data channel and provides diversified service guarantees for different types of users or applications in the factory.

- Push factory operating operational separation. The usage of operators 5G as an alternative or complementary factory original network, provide smart factory including office, logistics, production, management and a set of network plan, construction, and maintenance, unite by the operators monitoring network data, network security, provide timely network upgrade services, promote enterprise

network operations and operational separation, authors efficiency, promote the competitiveness of the enterprise.

With the rapid development of the industrial Internet, the 5G industry access gateway will contribute to the industrial field. In the smart factory application scenario, 5G industry access gateway can realize data transformation, data filtering, computing processing, historical data storage, statistical processing, alarm processing, service request, and other functions, whose specific parts are as follows：

- As a high-performance terminal device of 5G network, 5G signals are converted into WLAN signals and network cable access to provide wireless broadband access services for office users in the factory.
- Industrial mobile solutions, 5G NR of the era of high speed, low latency, characteristics will operate in the industrial field, and then solve the AGV automatic introducing car, production equipment, industrial robots, industrial facilities, which have industrial visual problems. Thus, wireless networking, wireless access terminal and remote management, data collection can be implemented to provide the background data source to realize the big data analysis.
- It adopts an HDMI interface with a programmable serial port (RS485/232). It can upload or connect devices locally through Ethernet, and also realize motion control functions such as machine arm and servo motor through EtherCAT so that the products can have real-time intelligent processing capability.
- Based on ARM architecture, integration, high-performance products, at the edge of the computing and communications gateway technology provides a rich computer interface, power plant automation production, improve production efficiency, equipment at the core of data acquisition and even to the cloud platform to realize the online monitoring and predicting application service, and

through the edge of computing capacity to meet future demand for the diversity of the expansion of service applications, to adapt to the present industry situation and the trend of the construction of the Internet of things.

- Supporting firewall, anti-attack, URL blacklist, and other security functions can provide a safe and reliable network environment for the factory to ensure industrial data safety.

4.3. Smart Port

Port industry upgrading demand is strong with new innovative technology acceptance. In the early stage, it focuses on the informatization of the office and logistics system platform. In contrast, it focuses on cost reduction and efficiency improvement, the production system's automation, and unmanned in the later stage. 5G network, with features such as large bandwidth and low delay, has a high degree of fit with port service requirements and a high degree of technical capability matching. It is one of the main directions of the 5G+ industry application at present. Smart ports mainly include a horizontal transportation system, vertical transportation system, ship entry, exit port system, overall security monitoring system, and other application scenarios.

The vertical transportation system is mainly used to load and unload containers and cargo tally operation at the wharf, which directly determines the production efficiency and economic benefits of the whole port. The vertical transportation system mainly consists of a bridge crane and gantry crane, which can realize loading and unloading containers from ship to shore, loading, and unloading boxes in container yard and cargo tally. Currently, 90% of the land bridge and field bridge is used for manual on-site aerial work, which requires remote control. The remote control is realized through an optical fiber, which is easy to wear out and challenging to transform and

upgrade. Through the tower crane cab use 5G industry access gateway via Ethernet protocol connection HD camera and tower crane control system, realize the control of ultra-low delay signal and HD video signal transmission, with 5G large bandwidth low latency features such as bridge crane, gantry crane remote loading and unloading operation, improve work efficiency, solves the fiber optic deployment issues.

The horizontal transportation system mainly realizes container transportation before the bridge crane and the storage yard. Traditional ports rely on manual driving collection cards, which are costly. Part of the newly built geomagnetic fixed lines of the port, with LTE-U to achieve unmanned driving. The port collection card control system controls the port terminal collection trucks remotely and in real-time. It requires a delay of 20~50ms, which is a typical low delay service. However, the geomagnetic cost is high, and flexibility is lacking. LTE-U has a small bandwidth and low-cost performance. Based on a 5G+ high-precision positioning scheme, it replaces LTE-U+ geomagnetic scheme with lower cost and better performance in bandwidth, delay, continuity, reliability, and other aspects. Similarly, control signal transmission with ultra-low delay through 5G industrial access gateway is a fast way to realize the horizontal transportation system's unmanned driving.

There is no set card remote scheduling for bridge cranes/gantry crane remote loading and unloading operation. Other typical applications of intelligent port custom 5G wireless networking scheme of the diagram below, the specific network scheme of port type equipment by 5G industry access gateway access to port production equipment are particular, and customized to optimize 5G network, data flow directly using local shunting device is routed to the port of cloud data center.

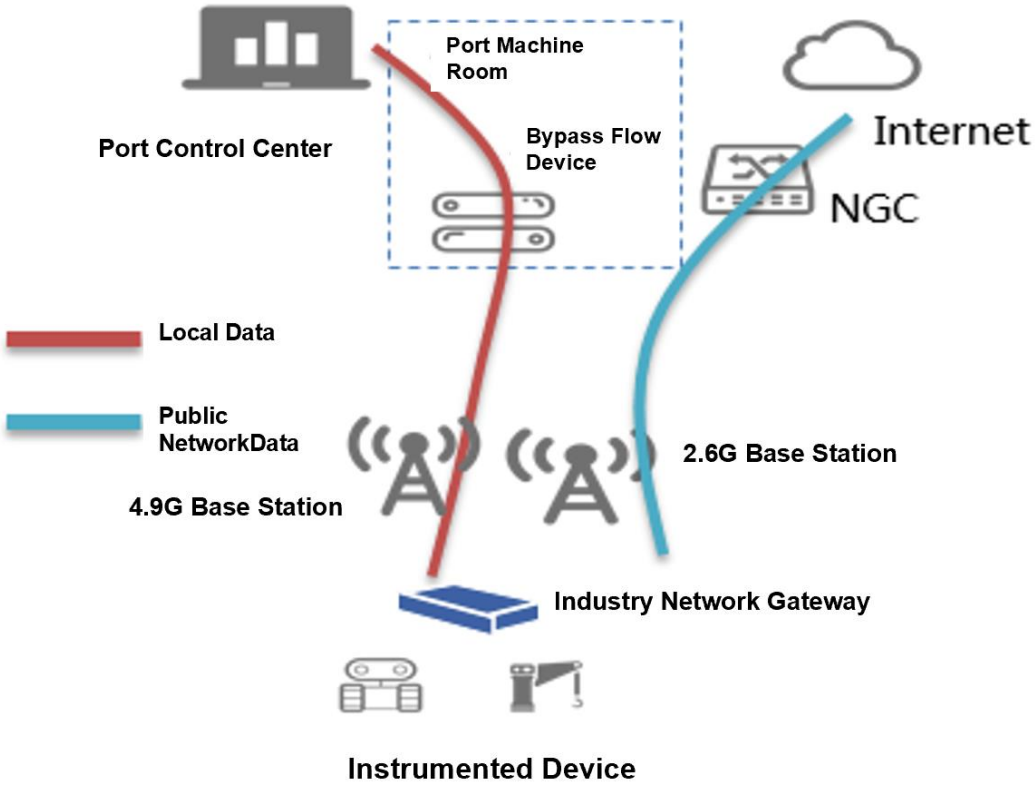


Figure 4-3. Smart port 5G wireless Networking scheme diagram

Port networks based on 5G have the following advantages：

- Based on Shared spectrum exclusive local use, the synergistic spectrum provides 2.6G or 4.9G range for ports based on service capacity requirements and physical isolation requirements, among which 2.6G range covers more widely and costs less 4.9G frame structure is more flexible, with lower latency and higher uplink bandwidth.
- Customized network, bridge crane and gantry crane emphasize more on uplink large bandwidth. Unmanned card service emphasizes more on low time delay and high reliability. 5G can provide customized network services for production users of different services.
- Data isolation: different levels of data isolation can be provided using base station

shunt, UPF sink, small core network, etc., to reduce communication delay further and ensure data security with high data confidentiality.

In the smart port application scenario, the main functions and functions of the 5G industry access gateway are as follows：

- Through rich access to 5G network for various port IoT equipment types and provide multiple types of IoT protocol conversion.
- It provides uplinked large-bandwidth network access for remote control scenes such as bridge cranes and gantry cranes to offer high-definition video transmission requirements for remote control and video surveillance.
- It provides low delay network data transmission for remote control scenarios such as remote control of port, wharf, and truck.
- It provides a rich computer interface to connect each dispatch subsystem and meet port intelligent dispatch demand through edge computing capacity.

Chapter 5 5G Industry Access Gateway Test

There are many types and forms of access gateways in the 5G industry, and their service functions and performance requirements are also different according to different application scenarios. Therefore, it is difficult to have a universal test scheme for access gateway in various 5G industries. However, the test scheme for 5G communication capability is still universal despite significant upper service applications.

Therefore, it is recommended for the 5G industry access gateway test to test the underlying communication capability and the upper service capability and the hardware reliability, respectively. To improve the test efficiency and reduce the test cost, the test of communication ability can be carried out based on the module or chip of access gateway integration. The upper-level service capability should be customized. The test should be carried out based on the terminal due to the extensive relationship between service capability and terminal form. The following part will study the 5G industry access gateway communication capability test and service capability test requirements.

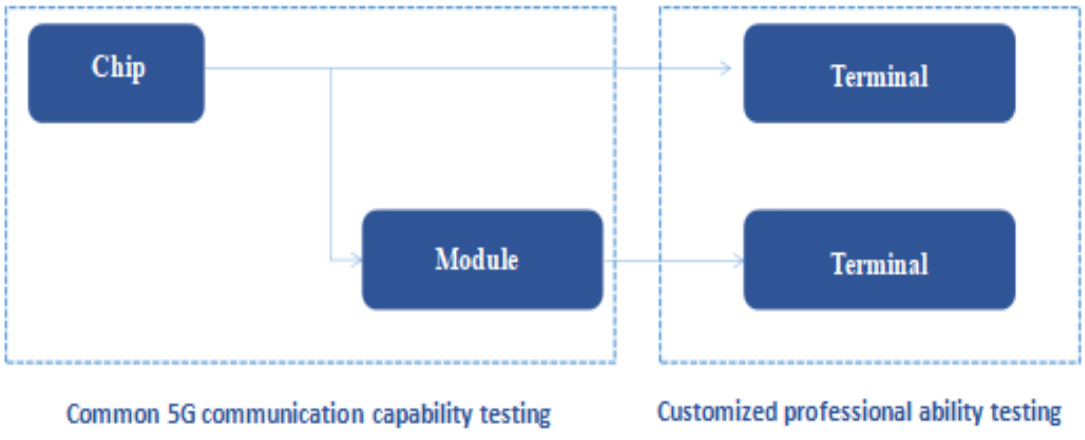


Figure 5-1. Schematic diagram of access gateway test scheme for 5G industry

5.1. Communication Capability Test

5.1.1. Instrument-based Conformance Testing

The consistency test is a universal standardized test method for wireless communication capability worldwide. Its test content's basic and comprehensive features are usually used to test whether the primary protocol function and performance index of the 5G terminal meets the requirements of the 3GPP core standard. In the actual test, the instrument can simulate different scenes through the simulated network environment to ensure test cases' stability, repeatability of test results, and high efficiency of test execution.

The basic protocol function, RF performance, and wireless resource management capability of access gateway can be investigated through protocol consistency, RF consistency, and wireless resource management capability consistency tests. Protocol consistency test is used to verify the correctness of the protocol stack implementation of 5G terminal wireless communication layer; Rf consistency is used to investigate the performance and demodulation of 5G terminal transmitter/receiver. Wireless resource management capability is used to analyze terminal performance on wireless link management, measurement accuracy, timing accuracy, and other aspects.

5.1.2. 5G Network Interoperability Test

The interoperability between 5G access Gateway and real network equipment needs to be verified to ensure the access gateway's good service performance in different networks.

Interoperability testing consists of laboratory testing and field testing. In terms of laboratory testing, specific test scenarios can be built through test equipment and test

tools to verify access gateway network access success rate, rate throughput, delay.

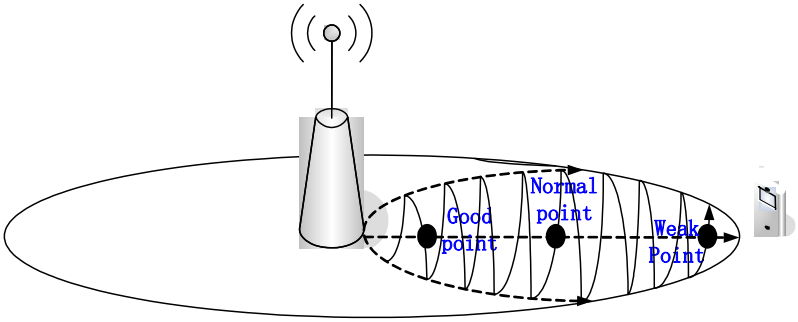


Figure 5-2 Test point selection in outfield tests

As mentioned above, the field test is mainly used to verify the access gateway's communication capability in the real network environment. For example, test points are selected according to access gateway usage scenarios. Fixed-point tests are conducted for functions and performance, such as throughput and service success rate under the existing network. For the access gate used in the mobile scene, it can pass the outfield running test, select the traffic road that can cover the main use scene, and test the terminal's function and performance in the mobile scene.

5.1.3. Performance and Special Scenario Test

To verify industry terminals' function and performance and complement the consistency test, test requirements, including performance tests and particular scenario tests, are proposed for different industry access gateway. In terms of function and performance testing, including the investigation of essential functions, mobility, power consumption, and throughput of terminals, to ensure the data transmission capacity of access gateway in different scenes and the absolute power value of data transmission in other states; On the contrary, for the application characteristics of different access gateways, such as the application of vehicular access gateways to the logistics and transportation industry, it is necessary to test the throughput service continuity of gateways in high-speed scenarios and investigate the demodulation performance of terminals at 120km/h and higher mobile speeds.

5.2. Service and Reliability Testing

As mentioned above, to examine the access gateway's communication capability, it is also necessary to verify its operational capacity. For different types of access gateway, its service function is quite different.

5.2.1. Service Capability Test

As the most critical function of 5G industry access gateway is to forward and manage data at the entrance of the industry network, it is suggested to make the following test requirements for its service capability：

- The number of concurrent connections: When the access gateway is used to store session concurrent connection information, system resources need to be used. This indicator refers explicitly to the processing capacity of the security gateway to the service information flow. It is the maximum number of point-to-point connections that the gateway can process simultaneously. It reflects the ability of security gateway devices to control access to multiple links and track connection status.

- VPN：5G industrial router, 5G industrial intelligence gateway, and 5G enterprise access gateway need to support the VPN function. For this indicator, the maximum throughput of data transmission through VPN tunnel and the maximum number of VPN tunnels that can be supported should be tested under the condition that the device VPN function is enabled.

- QoS：5G industrial router, 5G industrial intelligence gateway and 5G enterprise access gateway need to support network management functions, and need to test the degree of control granularity that can be achieved when

speed limitation is carried out on IP, and the degree of control granularity that can be achieved when bandwidth assurance is carried out.

- Anti-attack capability: 5G gateway needs to ensure that devices connected in the network are not attacked, so it needs to test the blocking capability of devices against malicious service attacks (such as UDP-flood, rank).

5.2.2. Hardware Reliability Test

As the industry scene's network entrance, the 5G industry access gateway has strict requirements for equipment reliability. Moreover, for the 5G industrial access gateway, due to the brutal scene in the factory, there are strict requirements on technical specifications such as temperature and vibration. According to the above conditions, the following hardware reliability test items are recommended：

- Temperature characteristics: 5G industrial access gateway needs to test temperature performance such as high and low-temperature start-up, high and low temperature working, high and low-temperature storage, and temperature cycling.
- Shell protection level: 5G industrial DTU, 5G industrial router, 5G industrial intelligence gateway, and 5G enterprise gateway need to meet the shell protection requirements stipulated in GB/T 4208-2017 according to the level specified in this research report.
- Adaptability to the mechanical environment: 5G industry access gateway shall meet the mechanical environment's adaptability requirements in Appendix 1.

Appendix

Appendix 1 Adaptability Test to Mechanical Environment

Test project	Test parameters	Test parameter value
Sinusoidal vibration test （working state）	Frequency range（Hz）	10～55～10
	Displacement amplitude（mm）	0.35
	The axial number	3
	Frequency sweep rate（oct/min）	1
	The duration of each axis upwards （min）	30
Impact test （working state）	Impulse waveform	A half sine wave
	Pulse duration（ms）	11
	Amplitude of acceleration	30g
	Impact axial number	3
	The number of pulses per axis	3
Free fall （working state）	highly（mm）	1200
	Number of geometric surface	4
	Drop number of each face	1