GTI Proximity Networks Lifecycle Management Based on Digital Twin White Paper

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1 Preference

In order to address the key requirements and existing problems of industry proximity network planning, construction, and management, this white paper proposes an industry proximity network lifecycle capability system based on Digital Twin technology and develops the industry proximity network Digital Twin Network Lifecycle Management (DT-NLM). This white paper is written in the following three aspects. Firstly, it gives an introduction to the core technologies involved in detail. Secondly, it provides several use cases of industry proximity network Digital Twin application. Finally, it makes suggestions for the industry through prospects. This white paper aims to provide reference and guidance for the industry when designing related projects and proposing solutions.

2 Abbreviations

Abbreviation	**Explanation**
IOT	Internet of things
NB-IOT	Narrow Band-Internet of Things
WIFI	Wireless Fidelity
Lora	Long Range
RFID	Radio Frequency IDentification
QOS	Quality of Service
SLA	Service-Level Agreement
AGV	Automated Guided Vehicle
TSN	Timesensitive Network
UWB	Ultra Wide Band
DT-NLM	Digital Twin Network Lifecycle Management Network Lifecycle Management
E-RAB	Evolved Radio Access Bearer
RRC	Radio Resource Control
BLER	block error rate
SNMP	Simple Network Management Protocol
RSSI	Received Signal Strength Indicator
RSRP	Reference Signal Receiving Power
SINR	Signal to Interference plus Noise Ratio
WIA	Wireless Networks for Industrial Automation
PDU	Protocol Data Unit

3 Overview of the DT-NLM system

3.1 Digital twin technology assisting the transformation of industrial digital intelligence

This idea of building virtual models to optimize flow, product, or service, has been emerging for a long time. However, with the wide application of digital simulation models with more complex abilities of simulation and modeling, better interoperability, IoT sensor, and visualization, companies gradually realize it is possible to build a more detailed and dynamic digital simulation model. Digital twin is a virtual entity that serves as the digital counterpart of a physical entity. It can use both historical and real-time data, along with algorithm models to simulate, verify, predict and control the entire lifecycle of physical entities. Traditional industries such as services, digital economies, and other scenarios have already applied this technology, specifically in the following two aspects.

First, digital twin that constructs the entire industry chain should be applied to promote the transformation of the industry to 'Service-Embedded Manufacturing'. Service-embedded manufacturing is not only a new digital industrial form that integrates manufacturing and service, but also a significant direction for the digital transformation and upgrading of manufacturing in the future. Customized production is one of the typical methods of 'Service-Embedded Manufacturing'. It not only takes the initiative to introduce customers into the process of product design, manufacturing, application and service, but also actively discovers customer needs, and launches targeted services. Based on platform cooperation, enterprises actively provide both productive services and service production for upstream and downstream customers in order to create value collaboratively. Based on integrating system engineering models in various fields, constructing digital twin from the entire industrial chain such as customers, market demands, supply chain, logistics system and maintenance guarantee, is a great help of promoting the transformation of traditional industries to customized production and achieving more agility and flexible business model. For example, in consumer markets, the head companies of shoemaking such as Adidas and Nike have established their digital strategy departments. With the mergers and acquisitions of IT and DT manufactures, they want to establish digital twin which are related to the shoe industry and finally achieve customized production and online marketing. From the traditional business model of distributing sports shoes, digital twin extend to the sports industry including group socializing, training, device marketing, and event organization, etc.

Second, digital twin which builds the real economy could be applied to promote the development of the digital economy. The digital economy plays an important role in various aspects such as giving impetus to the development of the industrial economy, increasing labor productivity, cultivating new markets, discovering new growth directions of the industry, and achieving both inclusive and sustainable growth. The core of the digital economy is data-driven development, different from that of the industrial economy which is oil and mechanical. By establishing digital twin of the real economy, capitalizing data, and establishing a complete set of digital service systems such as finance, will contribute to greatly reducing social transaction costs, improving the efficiency of optimal allocation of resources, and increasing the added value of products, enterprises, and industries in terms of simulating decision-making and guiding the rapid optimal allocation and regeneration of resources. For example, Alibaba has built an online e-commerce platform that gathers consumers, supply chains and manufacturers, and has become an economy with annual revenue exceeding 80% of the world's GDP. Also, Alibaba has built digital twin economy with shared intelligence. Every individual, such as consumers and suppliers, is a digital twin among them. By accurate portraits, Alibaba has established a credit system, payment system, personalized finance and other service products. Xiupinniu digital twin factory has proven digital

twin technology. It integrates the Internet of Things, big data, artificial intelligence, data three-dimensional visualization, and virtual simulation technology which adopts three-dimensional visualization digital sand table management. At the same time, it can integrate all docks, operate and manage data, and make maintenance management intelligent, integrated into scheduling, and transparent in production data. This technology is widely used in industrial production and manufacturing, engineering operation management, marine, military, aerospace, and other fields. It has been applied in enterprises such as China Communications Constructions Company , China Shipbuilding Industry Group, Dongfeng Nissan.
Digital twin is an enabling technology to build a new generation of digital infrastructure. It not only is becoming the backbone of economic and social "five vertical and three horizontal" development and the research hotspot of related industries but also has a foothold in various industries. It innovates the process in the whole value chain, and can continuously improve efficiency, reduce the failure rate to the greatest extent, shorten the development cycle, and open up new business opportunities. In other words, it can create a lasting competitive advantage

3.2 Overview of Industry proximity Network

Industry proximity network is a general designation, covering the network access technology of side devices in the industry proximity. It not only connects all kinds of terminals, machines, sensors, and systems at the end of the industry proximity but also satisfies various business needs of the industry proximity such as sensing, data, positioning, control, and management. Common industry proximity network technologies include industry ethernet, Fieldbus, WiFi, Bluetooth, ZigBee, and other short-distance communication technologies, NB-IoT, LoRa, SigFox, and other both with low-power and wide area network communication technologies, as well as 5G, TSN, millimeter wave, passive RFID, UWB, and other communication technologies.

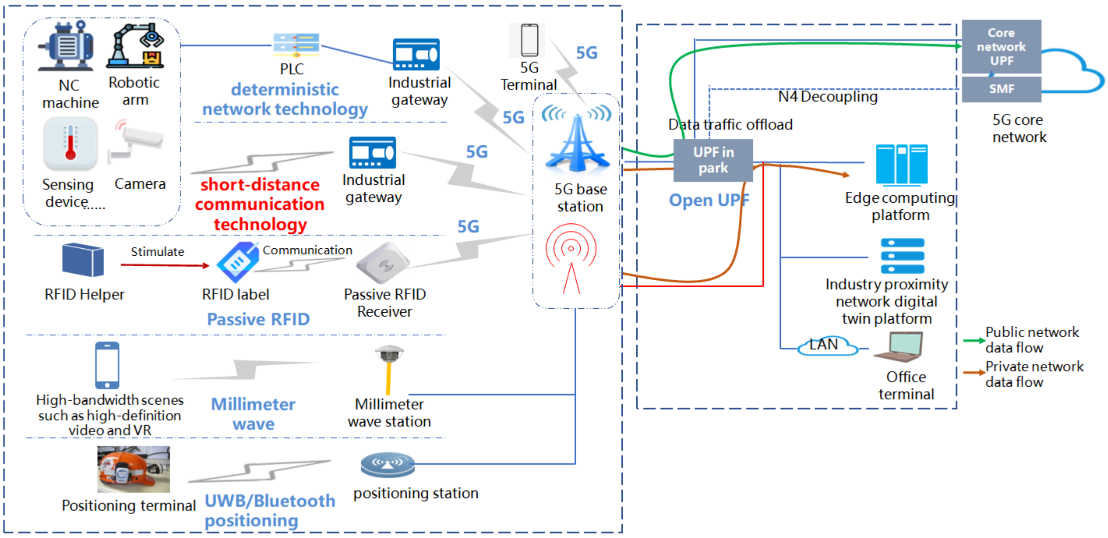

Figure 3-1 The structure of industry proximity network

Industry networks consist of the industry proximity access network and the industry proximity core network. Industry proximity access networks can bridge heterogeneous industry proximity network such as passive communication, short-distance communication, Bluetooth, and TSN. Compared with that, industry proximity core networks mainly refer to the UPF deployed on the edge of the industry proximity to perform data traffic offload. Its business is deployed on MEC to process the field operation data which is uploaded by 5G, in order to realize the management of the whole proximity network.
There are five core technologies in industry proximity access networks, including deterministic

network technology, new short-range communication, new passive communication, millimeter wave, UWB/Bluetooth high-precision positioning. Deterministic network technology not only meets the requirements of high reliability and certainty of communication, but also solves the complex problems of on-site wiring construction. The new short-distance communication is based on a new wireless air interface design. While achieving point-to-point communication, it can meet the needs of ultra-low latency, high reliability, precise synchronization, high concurrency, high efficiency, and high security. The new type of passive communication adopts a system architecture that separates incentives and communications. Tag incentives use radio frequency communications. Both control command issuance and information return use 5G, which improves the performance of RFID networking and realizes high reliability and efficiency of reading information in scenarios such as asset management. Millimetre wave can achieve fixed-point coverage in key regions while ensuring regional coverage, improving upstream transmission capacity, reliability, and security. UWB/Bluetooth high-accuracy positioning can ensure high bandwidth, low latency, and wide connection networks. At the same time, it can also solve the problems of low accuracy of traditional positioning using signal carrier intensity and poor adaptability to the environment, which meets the needs of high-precision positioning in scenarios such as collaborative work of vertical industry device, remote controlling, and trajectory tracking of mobile devices.

The industry proximity core network uses UPF net elements deployed on the edge of the industry proximity to offload the local data to meet the requirements of industry customers for data hiding and ultra-low latency, and realize the entire process of data transmission, processing, and result feedback ending locally.

In addition to the requirements for proximity network integration and data hiding, industry customers also put forward higher requirements for intellectualization and automation on operating complex network systems.

3.3 Challenge in the operation of the industry proximity network

As various industries enter the era of digital transformation, facing the new trend of rapid increment in the scale of terminal networking, the complexity and diversity of networking modes, and the reduced tolerance for network fault handling and recovery time of service operation, the traditional device-centric and firefighter-style network operation model is no longer suitable for the new needs of industry proximity network management.

First of all, with the rapid increment of the number of terminal networking and the complexity and diversity of the networking network, the monitoring of terminal operation status will be a part of network management. Taking IoT terminals as an example, the number of global IoT connections in 2018 has reached 7 billion, and it is still growing at an annual growth rate of 17%. Among them, 80% are wireless personal area networks and wireless local area networks. Proximity networking methods include NB-IoT, Bluetooth, WiFi, Lora, RFID, etc. The operation status of the terminal directly affects the operation quality of the network. It is necessary to perceive the operation status of the terminal network through probes and other means to strengthen the end-to-end management of the network.

Secondly, in the face of diversified application scenarios and terminal forms, solutions of industry proximity network and configurations need to be highly customized, and customers are willing to perceive the network. The diversification of terminal types, operating system types, service types, and QoS requirements has led to a high degree of customization of networking solutions, which requires one-by-one discussion and the assistance of specialized networking simulation tools. SLAs in different scenarios have different requirements for network performance. As a result, SLAs need to be managed in detail and guaranteed with determinacy. In addition, although customers are willing to perceive the network, they are not professional enough. They need the network performance indicators and operating status to be comprehensible and perceptible intuitively, real-time, and three-dimensionally.

Finally, as the digital base of networks, customers' tolerance for fault handling and recovery time is greatly reduced. As a result, the traditional passive fault recovery model cannot respond to demands quickly. More and more industries are introducing digitalization into production and customer services, such as AGV trolleys in warehouses, unmanned payment systems in supermarkets, and automated coal digging devices in mines. The network is the prerequisite for the normal operation of the application. Traditional operation is centered on network device. Considering the weakness among various device management systems such as independence, data isolation, difficulties in troubleshooting and trouble positioning, lack of automatic operation methods and tools, too many manual links in the operation process, if a fault occurs, it is a long period from complaint to the on-site investigation, and it is difficult to meet the requirements of rapid recovery from fault

3.4 Industry proximity network lifecycle management system based on digital twin

Digital twin will not only help the digital and intelligent transformation of the industry, but also play an important role in the proximity network lifecycle management. First, the visualization capability can solve the problem that customers need to display network performance indicators and operating status in an intuitive, real-time and three-dimensional manner. Secondly, the network planning and simulation capabilities can solve the problem that networking and configuration of the industry on-site are complex and diversified, resulting in a high degree of customization of the networking solution and a high cost. Finally, the intelligent operation capabilities can solve the problem that the traditional passive failure recovery model cannot quickly respond to the demand. After the failure occurs, the period from complaint to on-site investigation is long, and it is difficult to meet the problem of rapid failure recovery. As mentioned above, it is necessary to build an industry proximity network lifecycle management system. The specific capability plan is as follows:

1) Digital twin visualization capabilities of the industry proximity network. The system can provide multi-dimensional visualization functions of digital twin for the industry proximity network lifecycle, covering various stages of network design, network operation, and can provide industry customers with customized and visual end-to-end network solutions, network networking planning, and network construction progress monitoring. It can also provide visualization capabilities such as network operating status, network configuration, and network coverage.

2) Industry proximity network solution planning and simulation capabilities. The system can build a digital simulation model of the industry proximity network topology based on new passive, new short-distance, Bluetooth, TSN and other network technologies. Through the "drag-and-drop" operation of the simulation module, it can be convenient and efficient to realize industry proximity network solution planning and simulation functions. To quickly achieve networking requirements such as frequency band exclusive, uplink high-rate transmission, high-precision positioning, customized comprehensive coverage, high-reliability transmission, and meet industry customers' different production or management in complex application scenarios Links to the needs of heterogeneous network architecture and networking.

3) Industrial proximity network digital twin intelligent operation capabilities. The system is based on intelligent operation algorithms, combined with industry proximity network infrastructure operating parameters, business data, historical faults, alarm logs and other data. It can provide industry proximity network fault diagnosis, failure prediction, and self-healing maintenance services through twin simulation and other technologies.

4) Digital twin modeling capabilities of the industry proximity network. The system can provide twin modeling of device such as industry proximity network operation device, industry proximity network terminals, industry proximity network gateways, etc., including physical space models, mechanism models, semantic models, etc., to achieve the association of digital space and physical entities. It provides basic capability support for the simulation, visualization, and intelligent operation capabilities of digital twin industry proximity network during the network lifecycle of planning, construction, operation, and optimization.

4 Digital twin network lifecycle management （DT-NLM）

4.1 Brief introduction to DT-NLM

Based on the above background, the overall structure of DT-NLM is shown in Figure 4-1. The core business modules include data acquisition and management, twin modeling, etc., to achieve visualized management of device, network planning simulation, network real-time monitoring, network intelligent operation, and other functions, Its core idea is to manage the lifecycle process of the industry proximity network through the digital twin network concept and provide low-cost trial and error and high-quality industry services centered on network digitization.

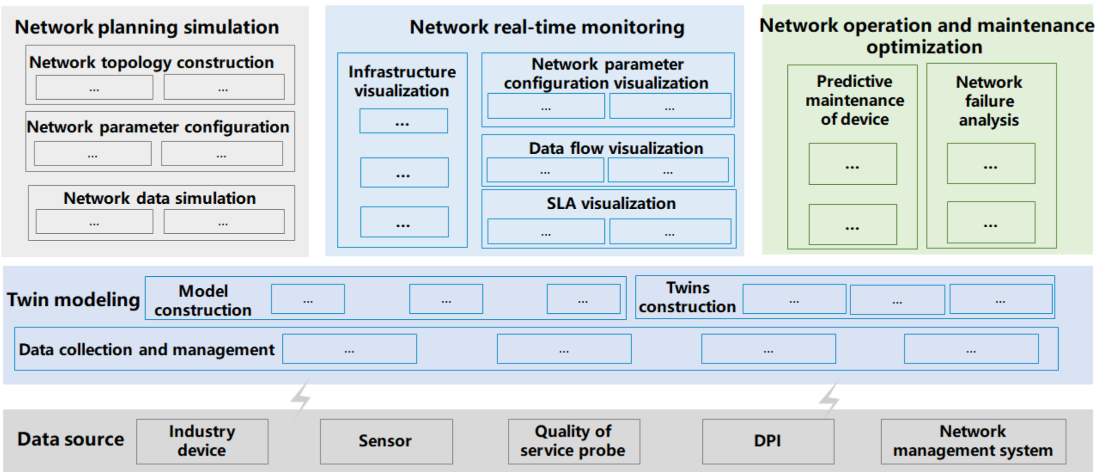

Figure 4-1 Overall structure of DT-NLM

4.2 Key technologies of DT-NLM

Through the planning of the platform's functional architecture and capabilities, the core technologies involved in platform R&D are focused on as shown in the Figure 4-2. The core technologies of the industry proximity network include data collection (probe monitoring and analysis platform plus probe), digital twin modeling, smart operation, etc. Through key research on these technologies, it provides a technical foundation for the iterative research and development of the network management capability system and platform.

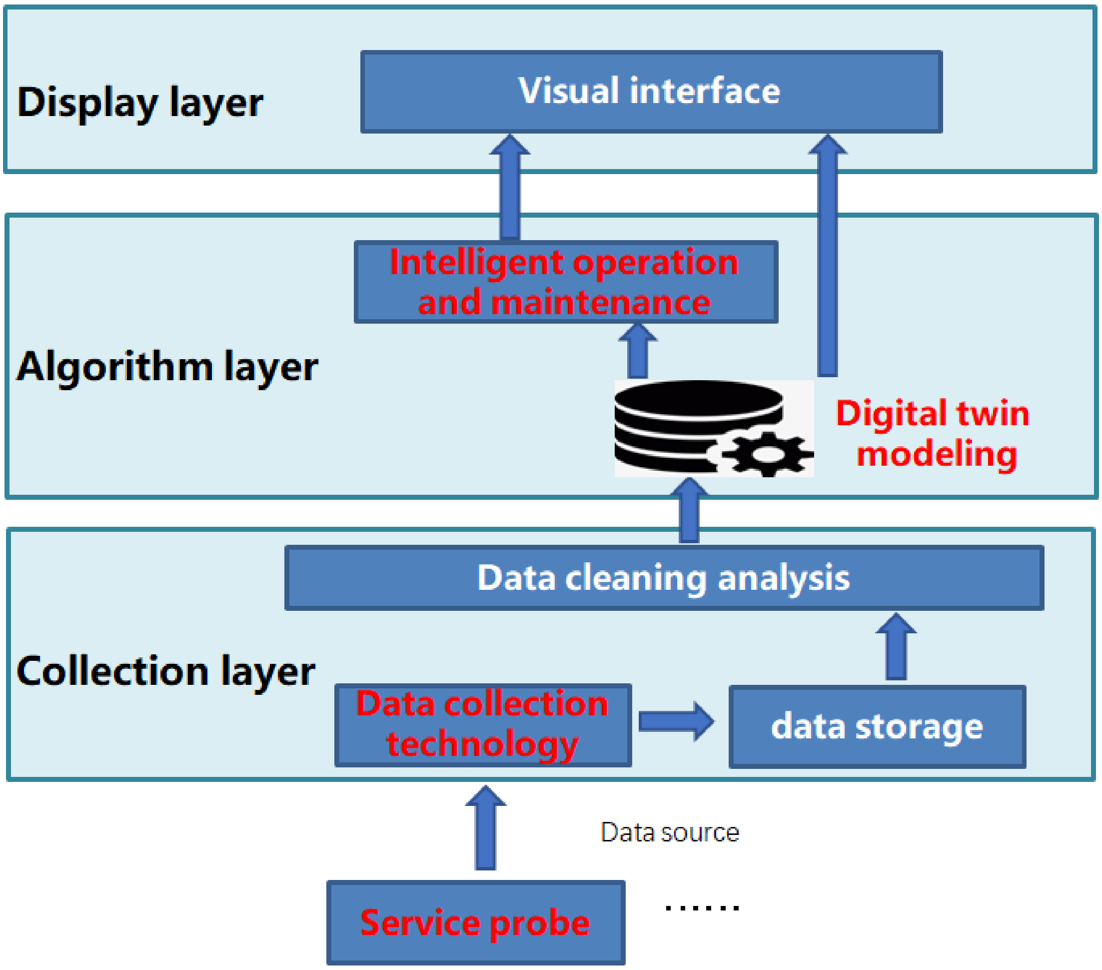

Figure 4-2 Key technologies of DT-NLM

4.2.1 Data collection technology of industry proximity network

1. Basic concepts and structures

Data collection and analysis are the core contents of network operation and management. Traditional data collection methods for network operation include packet analysis mode based on listening to network data packets, SNMP agent mode based on router MIB library, IP flow data capture form based on network probe with insertion technical, and data flow capture form based on network data flow technology, etc. However, the above data collection methods are mainly oriented to the network flow information acquisition of network elements, and the collection of end-side data information has not been considered.

China Mobile Research Institute proposed a method that based on 5G end-side service quality, probes collect end-side data, to provide real-time service quality dynamics of terminal device, networks, and industry customers for industry proximity network, to perform active service quality warning, monitoring, network analysis, and network optimization. It effectively makes up for the lack of end-side information, and further carried out effective business transmission guarantees to ensure the user perception of industry customers.

The 5G end-side service quality probe system consists of two parts: the probe SDK middleware and the monitoring and analysis platform. The research and development work has been completed, and the joint debugging and optimization with the 5G gateway are being carried out. The system architecture diagram is shown in Figure 4-3.

1) The first one is probe SDK middleware. Probe SDK middleware is mainly responsible for the collection and monitoring of industry-level key data information. The probe SDK middleware has two deployment methods in the terminal. One is to combine the probe SDK middleware with the 5G module, and directly collect data in the module. Another is the combination of the probe SDK middleware and the terminal's AP, and the terminal processor controls data collection.

2) The second one is the monitoring and analysis platform. The monitoring and analysis platform is the nerve center of the entire system. It is mainly responsible for data collection and storage, issuing monitoring strategy configuration, and realizing data analysis, forwarding, display, device management, and other functions. For sensitive device data and detection data, the platform needs to be deployed on the internal platform of the park, so that production data does not exit the regional private network. For insensitive non-production data, the test server and monitoring analysis platform can be deployed on the external platform of the park and use the 5G public network to transmit data.

2. 5G end-side service quality probe data collection category

Oriented to industry customers' 5G or IoT business data collection requirements, the 5G end-side service quality probe system needs to provide field-level device status, network coverage, service quality, and other key information collection, monitoring, and analysis services to further develop effective service transmission guarantees, and to ensure the user perception of industry customers.

1) Terminal device data collection: The collected terminal device data mainly includes basic gateway information, such as gateway SN, CPU model, etc., gateway status information, such as power-on time, CPU occupancy, etc., and connected device information, such as device name, Device IP, etc.

2) Network coverage data detection: The network coverage data involved mainly include network signals quality parameters, such as SINR, etc., throughput performance parameters, such as uplink and downlink peak rates, etc., and cell-related information, such as access cell ID, slice ID, etc.

3) Service quality data monitoring: The service quality data involved mainly include general service quality information, such as network bandwidth, network delay, etc., video service quality information, such as video resolution, video frame rate, etc., and remote-control Service quality information, such as packet loss rate, delay, etc. The probe SDK middleware implements general-purpose service quality information detection functions by calling tools.

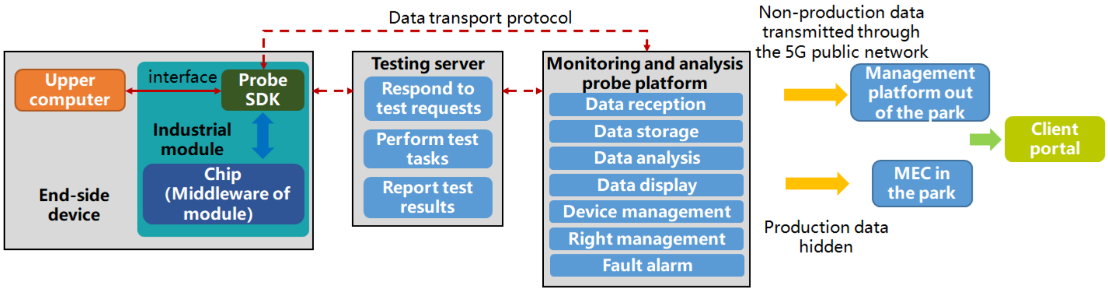

Figure 4-3 The architecture of 5G end-side service quality probe system

4.2.2 Digital twin modeling technology

Digital twin modeling technology realizes the mapping of the entity from the virtual space to the physical space. Through the analysis and decision-making in the virtual space, interactive instruction is formed to intervene and control the physical space, so that the whole physical system can keep a good operation state. In the industry proximity network, digital twin modeling is the original sub digital model that maps physical entities such as human (network operation personnel), machine (network element device), network (5g network and proximity network), method (operation manual, operation instruction, and other network knowledge), and ring (field environment) to the original sub digital model of virtual space. It arranges and combines atomic models according to network topology relationship and business requirements, and supports the intelligent requirements of the industry proximity network, such as visual, manageable, and controllable. Among them, the visualization of networks can be directly completed in virtual space. The management and control of the network need to feedback the instructions of virtual space analysis and decision-making to the physical space to realize the control of the physical entities of the network, such as fault alarm, work order distribution, network repair, network optimization, etc. The overall framework of digital twin modeling of industry proximity network is shown in Figure 4-4.

The digital twin model of industry proximity network includes geometric model, information model, and mechanism model. The geometric model is to express the interaction relationship with the physical space entities and entities in the form of two or three-dimensional graphics in virtual space and realize the visualization of network device, network topology, network fault, and other information. The information model realizes the standardized semantic description of physical entity attributes capabilities, interfaces, and data flows. Through the information model, the data from physical space can be transferred to virtual space in a standardized way for visualization and intelligent analysis. The purpose of the machine model is to reflect the objective law of physical space, and then manage and control the physical space entities. The mechanism model is divided into three categories:

1) The first one is the operating mechanism of device or system expressed by an explicit mathematical formula.

2) The second one is a rule set or knowledge map based on the experience of the domain experts in the process of work.

3) The third one is an AI mechanism model of machine learning algorithm training based on big data.

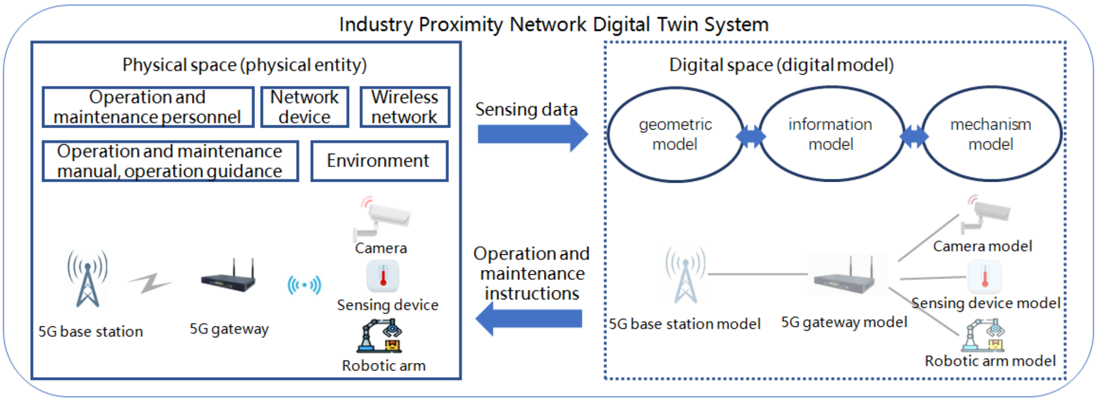

Figure 4-4 Framework of digital twin modeling of industry proximity network

4.2.3 Intelligent operation technology

The industry proximity network has the characteristics of complex network and diverse user demands. Operators will face more and more pressure and challenges in network operation. There has been a gap between the traditional manual operation mode and the advanced nature of the network itself. The difficulties and challenges in operation have also become increasingly prominent. The fault location and analysis are difficult, and the existing passive response operation mode is inefficient and the customer experience is poor. It is urgent to introduce intelligent proximity network operation technology to empower the operation business. The automation and intelligent operation ability centered on customers and business shall be formed, the operation efficiency and the customer network experience shall be improved. Finally form a high-value network operation management system.

In the proximity network, the industry terminal device (such as CNC machine tool, mechanical arm, sensor device, etc.) is connected to 5G edge gateway through WiFi, ZigBee and other networks. 5G edge gateway is connected with 5G base station through 5G network, which together forms the network system of the proximity network. The performance of network element devices such as industry terminal, 5G gateway, base station and the network status among these elements are the main factors affecting the operation of industry business and the network experience of industry customers, and are the key objects of intelligent operation of proximity network. Based on the location of the fault, the typical faults in the industry proximity network can be divided into 5G private network failure and proximity network fault, as shown in table 4-1.

Table 4-1 Typical faults in the industry proximity network

Typical faults in the industry proximity network	Fault names
5G private network failure	Base station parameter configuration abnormal, antenna feeder failure, device reset problem, software problem, hardware module failure (power module failure, carrier unit failure, main control board failure, optical module failure), etc.
proximity network fault	Coverage, interference, access, authentication, roaming and device failure (terminal device failure, gateway device failure), etc.

Based on the characteristics of the proximity network, through a comprehensive analysis of the proximity network operation objects, typical failures, etc., an industry proximity network intelligent operation program oriented to the proximity network plus 5G private network is formed. The plan shown in Figure 4-5 is based on service quality probe data (device basic data, network coverage data, and service quality data), unified network management system data (KPI, MR, KQI, live network failure, abnormal performance information) and terminal side data, using intelligent operation algorithms to train the intelligent operation model of the industry proximity network to realize intelligent applications such as fault delimitation, fault scene identification and root cause location, and fault prediction.

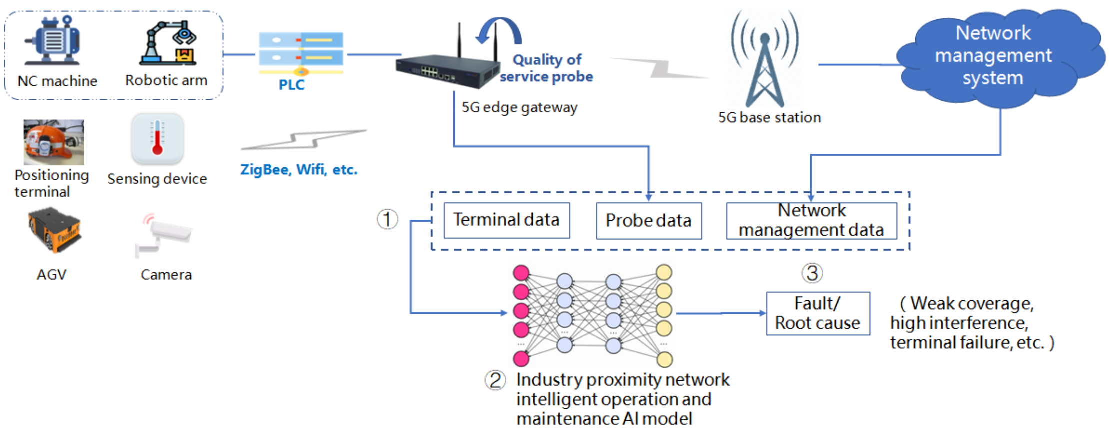

Figure 4-5 Intelligent operation framework of industry proximity network

4.2.4 Digital twin visualization technology

Data visualization:

In short, it is about the scientific and technological research on the visual representation of data. It is a concept of continuous evolution and expanding boundaries. It mainly refers to the basic information processing by means of graphics and visualization technology. Through 3D scene real-time rendering and data modeling, it can visually interpret the data, display real-time data and realize visual interaction. Data visualization is closely related to information graphics, information visualization, scientific visualization and statistical graphics.

Data visualization decision based on digital twin:

Digital twin emphasizes simulation, modeling, analysis, and auxiliary decision-making, focusing on the reproduction, analysis, and decision-making of physical world objects in the data world, while visualization is the real reproduction and decision support of the physical world.

1. Large scale full-scale multi-source data integration

One of the key features of digital twins is the integration of heterogeneous data from multiple sources. The visualization decision system also focuses on the integration and comprehensive application of heterogeneous data. The visualization decision system integrates the data generated in the actual operation of each industry, to provide data reference support for the industry operation research and judgment.

2. Visual analysis and decision support

Digital twins can provide the basis for actual business decision-making. The most practical significance of the visual decision system is to help users to establish digital twins in the real world. Based on the huge amount of data information, the business decision model is established by data visualization, which can evaluate the current transaction development status, diagnose problems in the past, and predict the future trend, so as to provide a comprehensive and accurate decision basis for the decision-making of managers.

3. Build digital twin to help intelligent decision-making

The final landing of any new technology needs to be changed from theory to practical application, so is digital twin technology. With the development of the times and the continuous progress of information technology, digital twins are given new significance. Digital twin technology will also play an important role in more and more fields and application scenarios.

Data visualization technology:

Visualization involves technologies including GIS geographic information system, 3D visualization (unity3D, WebGL/canvas), BIM, etc.

GIS geographic information system: it is a specific and very important spatial information system. It is a technical system that collects, stores, manages, calculates, analyzes, displays, and describes related geographic distribution data in the entire or part of the earth's surface (including the atmosphere) space under the support of computer hardware and software systems.

3D visualization: Unity3D: Unity is a real-time 3D interactive content creation and operation platform. All creators, including game development, art, architecture, car design, and film and television, use Unity to turn their ideas into reality. The Unity platform provides a complete set of software solutions that can be used to create, operate, and realize any real-time interactive 2D and 3D content. WebGL: WebGL (full-written Web Graphics Library) is a 3D drawing protocol, this drawing technology standard allows combining JavaScript and OpenGL ES 2.0, by adding a JavaScript binding of OpenGL ES 2.0, WebGL can provide hardware 3D accelerated rendering for HTML5 Canvas. Canvas: HTML5 tags, used to draw images (through scripts, usually JavaScript. The canvas element itself does not have the ability to draw. It is just a container for graphics, and scripts are needed to complete the actual drawing tasks.

BIM: BIM generally refers to building information modeling. Building Information Modeling is a new tool for architecture, engineering, and civil engineering. The term building information model or building information model was created by Autodesk. It is used to describe those computer-aided designs that are mainly three-dimensional graphics, object-oriented, and architecture-related.

5 Use cases of digital twin industry proximity network application scenarios

5.1 Use case of digital twin 5G converged industry proximity network

Industry on-site scenes are complex, and the phenomenon of network heterogeneity and customization is common. In addition to the requirements of the industry proximity network for network integration and data hiding, enterprise users also put forward higher requirements for the operation of complex network systems. Traditional operator network management and agent maintenance teams cannot meet the operation and management needs of industrial networks.

Industry proximity network for smart manufacturing not only need to consider diversified wireless access technologies to meet the operation and management requirements of industrial networks where multiple networks coexist in the industrial field, but also consider how to efficiently converge to 5G cellular networks to solve the problem of 'last 100 meters' in the field connection of IoT. Figure 5-1 shows the overall architecture of the 5G integrated industry proximity network. The architecture mainly includes two parts: the industry proximity access network and the industry proximity core network. Among them, the industry proximity access network can bridge heterogeneous industry proximity network, such as passive communication, short-distance communication, Bluetooth, TSN, etc. The industry proximity core network mainly refers to the UPF deployed on the edge of the industry proximity to perform data traffic offload and processing. The field operation data uploaded by 5G realize the management of the overall proximity network. Through the collaboration of 5G cellular wide-area communication technology and various proximity network technologies, it not only expands the wireless coverage, but also completes the local traffic offload of production data and uploads to the cloud, and realizes the unified access and unified management of 5G to short-range communications, and improves the operation of the factory dimension efficiency.

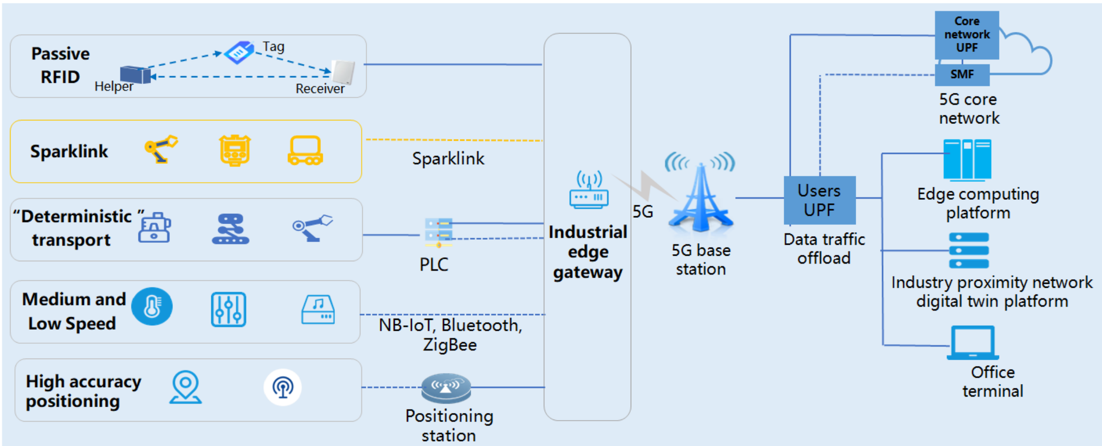

Figure 5-1 Overall architecture of the 5G integrated industry proximity network

Digital twin industry proximity network platform is based on the network service of the digital twin technology, defines a complete industrial network and process that supports self-optimization capabilities, including wireless connections, the interaction between factory networks and 5G networks, and provides information modeling and label identification oriented to industrial proximity networks, and model-driven intelligent network operation. The platform can realize network visibility, manageability, and control. It greatly reduces on-site operation and maintenance costs and improves industry on-site network service efficiency.

In the new type of 5G integrated short-range communication, short-range is responsible for field wireless communication, replacing wired networks such as field bus and industrial Ethernet. 5G extends the wireless communication range and helps data stored in the cloud. Relying on improvements in low latency, reliability, and anti-interference, Sparklink coordinated communication with 5G cellular technology not only improves networking flexibility, and reduces wiring costs, but also realizes the further extension of 5G business to the core of factory production. It provides higher-level flexible manufacturing, alleviates the problem that short-distance wireless communication technologies such as Wi-Fi, Bluetooth, ZigBee, WIA, WirelessHART, etc., are difficult to enter the key link of industrial production due to the inherent defects of time delay and reliability.

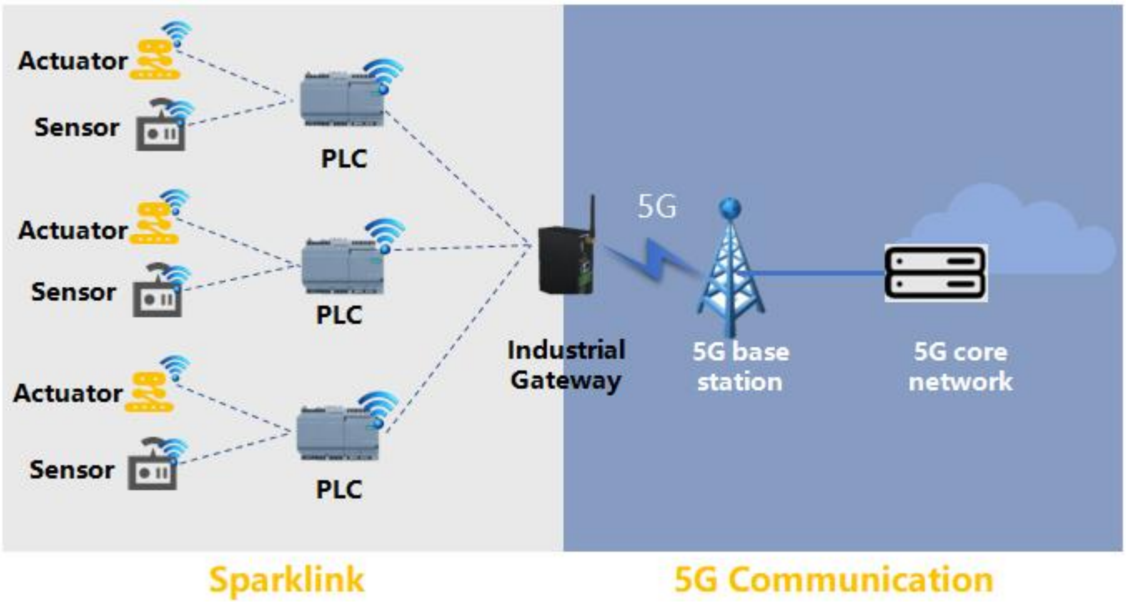

Figure 5-2 New type of 5G integrated short-range communication

5.2 Use case of distributed RFID innovation scheme and operator network collaboration

Traditional passive RFID technology is widely in demand in traditional clothing, logistics, and other cost-sensitive industries. However, it has problems such as self-interference, short-distance communication, and difficulty in networking. 5G plus new passive communication adopts a system architecture that separates incentives and communications. Tag incentives use radio frequency communications, and 5G is used for control command issuance and information return. It can improve RFID networking performance and realize high reliability and efficient reading of information in scenarios such as asset management.

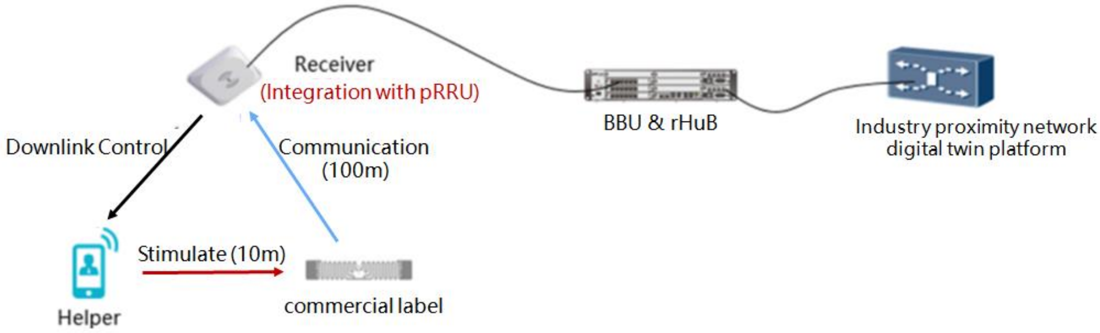

Figure 5-3 5G+new type of digital twin passive proximity network

The separation architecture innovation program has been systematically tested and verified in automobile factories and logistics warehouses, breaking through key business requirements such as full reading, fast reading, and accurate positioning in industry applications. Based on key technologies such as multi-antenna reception and multiple-helper coordination, it can achieve a 99.99% reading success rate in and out of the library, significant manual loss, and improved industrial production efficiency. In the scene of multiple crossings in and out of the warehouse, one receiver can carry multiple helpers, and the accuracy of the judgment of the inbound and outbound direction can be achieved by 99% through the time sequence relationship of the activation of the tags by the helper. And because one receiver can coordinate management and scheduling of multiple helpers, in actual commercial deployment, there is no need to install screen doors at the entrance and exit of the warehouse, and it can also effectively solve the problem of label information cross-reading between multiple crossings.

The receiver is integrated with a remote radio unit (Pico Remote Radio Unit, pRRU) in hardware for pRRU sites and transmission resources. Indoor cellular small base stations use passive communication device as one of the atomic capabilities to connect to external data networks. The digital twin industry proximity network platform is responsible for the PDU session layer and the corresponding address management, mobility, QoS, policy, security, and other functions to achieve network connectivity deployment and operation management.

6 Outlook

With the diversification of business requirements, the application scenarios of vertical industries are becoming more and more complex, and the phenomenon of network isomerization and customization is widespread. Traditional network management systems and operating systems cannot meet the needs of industry network management. Considering the above, operators need to transform networks oriented to vertical industries. The management idea is to evolve from traditional public network construction and maintenance to the network life-cycle management (NLM) of customized industrial networks and build an industrial network management capability system from the dimensions of "planning, construction, operation, and optimization" based on digital twin technology. Customer service and business assurance are the cores of low-cost trials, high-quality operation, and intelligent decision-making capabilities.

The DT-NLM platform is based on three-dimensional visualization, data analysis, twin simulation, etc. to realize the "visible, manageable, and controllable" of the entire business process. It builds a complete industry network capability from the perspective of network lifecycle management, and comprehensively supports the implementation of government-enterprise line solutions. The platform improves the network perception of industry customers and the efficiency of network construction and operation of local and municipal companies and brings three core values of low-cost trials, intelligent decision-making and high-efficiency innovation, which helps enterprises transform into digital intelligence.

In the future, we will work closely with industry partners through the DT-NLM platform to jointly formulate industry terminal, network device, and other digital twin model standards to promote industry standardization. We plan to share platform capabilities of digital twin modeling and orchestration simulation and create digital twin industry proximity network lifecycle management solutions applied to different scenarios to achieve win-win cooperation.