Green Point Technology: Connecting Robot Arms to 5G Networks

From manual collection by administrators to automatic data reporting by devices, ultra-large-scale device networking featuring ultra-low latency has been realized in the 5G era. With the help of 5G private network, all the challenges, such as difficult line transformation under frequent changes of production lines, high latency in equipment networking and sampling, and lack of management of high-value machines have been resolved. Now the time taken to change all the production lines has been reduced by 60% and the production line yield increased by 2%. These remarkable results are credited to 5G digital transformation.

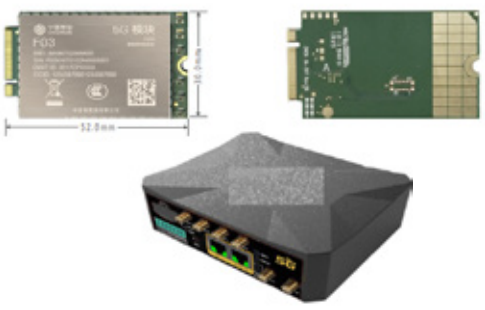
Zhou Meng
JGP CTO, Jabil Green Point Group

Partners JABIL GREEN POINT · 中国移动 China Mobile · 镭云科技 ZIYUN TECHNOLOGY

Case Overview

In the industry of 5G smart factory, China Mobile, Green Point Technology (Wuxi) Co., Ltd., and Ziyun (Shanghai) Internet of Things Technology Co., Ltd. worked together to launch the 5G robot arm networking project in May 2021. By deploying the highly reliable 5G private network and using the 5G edge computing gateway integrated with China Mobile F03X 5G module, thousands of Fanuc robot arms have been connected to the 5G network. Centralised computing has been replaced by distributed computing thanks to the edge computing capability on the gateway side to perform transmission of ultra-large equipment logs, program distribution and remote control, thereby meeting the ever-changing needs of the production-oriented enterprises for innovation.

In the 5G private network, the 5G edge computing gateways integrated by Ziyun are directly connected to the robot arms one on one. A registration request from the 5G module side connects a robot arm to the 5G network and assigns a fixed IP address in the private network. In case of central server failure or other emergencies, the box may be used as a cache and continue to upload data after recovery, guaranteeing the data integrity and security. Furthermore, the data packets are uploaded to the cloud after edge analysis, and the servers are distributed in a cluster to support high-concurrency and massive data computing. The 5G private network can meet the requirement of data collection latency within 50 ms, and help plants realize flexible production and visualised management of equipment. The calculation shows that the robot arms connecting to the 5G network may save the factory CNY 8 million/year in terms of the wiring cost. The project has been put into commercial use and has become the largest project using networked robot arms to collection data under the 5G SA mode in China. With the help of 5G and edge computing, factory devices become "conscious" and are able to "learn by themselves" and "manage themselves", increasing the production efficiency and yield by 15% and 2%, respectively, and reducing the production cycle by 10%.



Industry Challenges

Production lines often feature complex processes and many types of devices, mostly foreign brands, and their systems are incompatible with each other. As electronic products are upgraded very quickly, the need for flexible manufacturing will lead to frequent adjustments o production lines and changes in the layout of production lines, devices and logistics in plants. Supporting production devices also need frequent process upgrading.

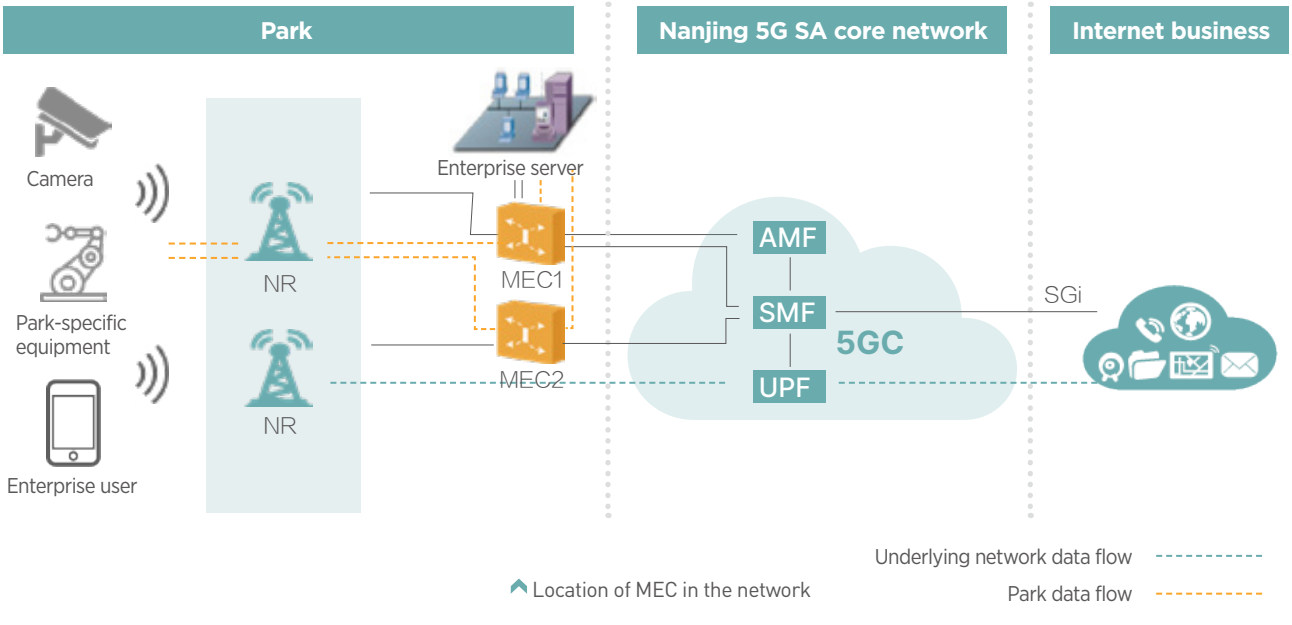
In addition, electronic information products are knowledge- and technology-intensive products. The products value quality, energy saving and environmental protection, follow industry standards and international standards, face fierce competition, and are upgraded very quickly. Electronic information products are divided into many categories which vary significantly. Although the manufacturing processes of different products are different, they generally follow the idea of modular design and modular production, which covers the whole production process from modules, components to the complete equipment.

Based on the need for digital transformation and the pain points of production, the project introduces an efficient 5G cognitive network at the edge and an intelligent industrial brain in the cloud. In other words, based on the abundant industrial interfaces and equipment protocols with wide coverage, a centralised industrial data collection gateway at the edge enables the connection of equipment to 5G network and the collection of full data in industrial scenarios, issuance of process documents and instructions, and one-stop solution for enterprise IoT equipment networking and data migration to the cloud. An industrial knowledge graph is established on the cloud platform based on industrial knowledge, experience and production practices to support high-level intelligent production applications such as product quality tracing, predictive maintenance of equipment, and factory digital twin.

Experiencing off and peak seasons, Green Point Wuxi site increases or decreases the production capacity at any time depending on customers' orders, and needs to adjust its production lines (at least twice a month) to fit the different products of customers in the upper reach, for example, Apple. Over a thousand CNC machines and robot arms in the factory were originally wired with traditional network cables, which requires long construction period, high costs and is difficult to adjust. Now the 5G-based flexible production lines may ensure efficient change of production lines. At present, the production in the factory is performed in a black box without efficient utilization, maintenance and management of equipment or visualized monitoring. In addition, the frequent equipment data collection in many point locations relies on strong computing power and an end-to-end latency within 50 ms to ensure real-time data collection, which requires highly stable and secure communication. The 5G private network enables local data traffic offloading through UPF to ensure latency of less than 30 ms while avoiding the security risks caused by data leakage.

Solutions and Benefits

To tackle the above problems, a solution was formulated as soon as the project started to build a 5G private network with high reliability and low latency using MEC. MEC is a "hardware + software" system that reduces latency in network operation and business interaction by providing IT service environments and cloud computing capabilities at the edge of 5G mobile network. Being close to the edge side of the networks of "things" and "data sources", MEC is an open platform that integrates core capabilities such as networks, computing, storage and applications. MEC provides edge intelligent services in nearby environments to meet the key needs of industry digitalisation for agile connection, real-time operation, data optimization, intelligent application, security and privacy protection. The following picture shows the location of MEC in the network:



5G+ Smart Manufacturing

After the network was deployed, CNC devices and robot arms in the factory were connected to the 5G network by installing 5G gateways in batches. In this way, the adjustment to production lines was not restricted by wiring, and the constraints of industrial WiFi network on high-concurrency data and latency caused by the excessively long transmission link of 4G networks were also avoided, making the expansion of production capacity faster, more flexible and agile. At the same time, to solve the issue of insufficient cloud computing power of the central cloud due to the access of massive devices, a customized 5G edge intelligent data collection gateway integrating functions such as protocol conversion, data screening and analysis was developed. Data packets can be uploaded to the cloud and interact with the company's MES system at high speed for quick judgment and marking. Based on the underlying device networking and data collection, the project built a data analysis platform and conducted targeted interface development and data conversion to help Green Point with the monitoring of key equipment and data throughout the entire production process and handling of exceptions, and contribute to the innovations in intelligent manufacturing and production model at Green Point.

For large manufacturing enterprises like Green Point, smart factory applications such as intelligent management of devices, product quality tracing and digital twin are developed quickly to help the enterprise achieve digital transformation and full 5G connection in the following main application scenarios:

01 Connection of massive devices to the 5G private network

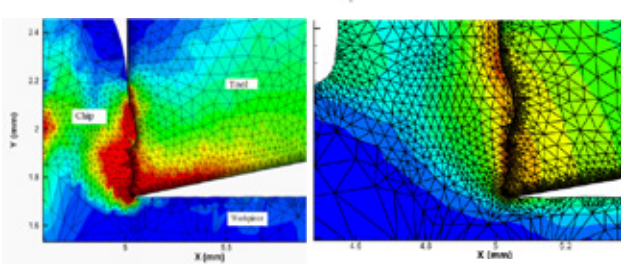
Industrial-grade edge computing gateways were installed on the 3,087 robot arms and CNC devices to be connected to the network to realise the connection of devices to the 5G network and data processing at the edge. The 5G edge computing gateways are directly connected to the devices one on one. In case of power failure or server failure, the box may be used as a cache and continue to upload data after recovery, guaranteeing the data integrity. At the same time, after edge analysis, the analysed data packets are uploaded to the cloud, and the servers are distributed in a cluster to support high-concurrency and massive data computing with balanced load and high processing performance.

02 A visualization platform for IOT data collection

A visualization platform for IOT data collection is used to aggregate and analyse the collected data. The platform accommodates all data-related functions, including storage, processing, collection and labelling. Regarding data processing, data labelling is important for quickly generating sample data, so that the model can be trained to predict new data.

03 Modelling and process simulation based on underlying data.

Big data mining and modelling are conducted based on equipment usage and maintenance to build a model of equipment quality assessment index and predictive equipment maintenance. Additionally, process simulation is carried out to build an equipment maintenance knowledge graph and a big data model on product quality. For example, for the predictive maintenance of equipment motors, data on motors such as voltage, current and torque are collected through the gateways of IoT platform to build a data analysis model for lifespan prediction. Predictive maintenance is expected to reduce a single repair time by 50%.



04 Remote control

To eliminate the need to debug and configure every workstation on site, the project realizes the remote control verification of the CNC processing centre through the reverse control of the networked devices, and grants access to the equipment remote control system on the platform. The system displays the real-time statuses of the devices and pushes alerts, clears the general alerts from a specific device, and changes the parameters and programs of the devices remotely, so as to ensure transparency for jobs, strong remote monitoring and intelligent fool-proof operation, significantly improving the efficiency of trouble shooting.

This is a great demonstration project for the large-scale commercial use of 5G networks in a production environment, and it is of great significance in setting an example of applying 5G networks and edge computing widely in industrial manufacturing areas. Based on this project, more efforts will be made to explore and develop more innovative solutions in intelligent manufacturing, focus on the real demands of enterprises, further help them reduce costs and increase efficiency by reducing manpower and improving production capacity and quality, and facilitate the large-scale implementation of intelligent manufacturing technologies in the industry field.

Summary and Next-Steps

After several months of implementation, the 5G-based equipment networked data collection has met the requirements for production. The 5G wireless signal has covered more than 30,000 square meters of the plant area, and the 5G network has met the following indicators for quality:

<1%
Packet loss rate

<15ms
One-way latency <15 ms (5G DTU to server)

>300Mbps
5G bandwidth > 300 Mbps

95%
5G coverage probability = 95%, SS-RSRP > -90 dbm

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