Research on 5G+MEC Industrial Internet Technology Testing Platform

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Abstract—The 5G+MEC Industrial Internet technology test platform is committed to the application of 5G technology in industrial scenarios. The test platform is supported by 5G+MEC as the technical architecture, and is integrated with machine vision, AR, AGV and other applications; The test platform adopts a modular design. Starting from the test scenarios of the manufacturing process such as interaction, customization, and production, some technologies are transformed into mature solutions through testing, which shortens the application cycle of new technologies and promotes the development of the Industry. Internet.

1. INTRODUCTION

Driven by policies, in recent years, China's Industrial Internet, 5G and other new infrastructures have developed well. 5G network construction has taken the lead in the world, but the integration of 5G + edge computing and Industrial Internet is still in technical research, laboratory testing, and scenarios. In the pre-commercial stage, there is little exploration of the application of industrial scenes. The problem to be solved at this stage is to promote the development and leadership of 5G applications and Industrial Internet in China through the application and verification tests of 5G in the industrial field[1].

In order to promote the industrial application of 5G and other wireless technologies, the research based on the 5G+MEC Industrial Internet test platform combines various advanced intelligent manufacturing technologies and fifth-generation mobile communication technologies to output intelligent manufacturing upgrade solutions in the 5G environment. The Internet platform provides technical capability support[2-4].

2. TEST PLATFORM INTRODUCTION

2.1. Test platform target

The 5G + MEC Industrial Internet Test platform aims to promote the in-depth integration of 5G and industrial intelligence technologies in the direction of industrial applications, accelerate the formation of a manufacturing networked industrial ecosystem, and can drive the improvement of the technological capabilities of the entire industry chain upgrading. The test platform combines the three major characteristics defined by 5G technology with actual industrial scenarios to meet and solve the needs of device interconnection and remcosystem, the popularization of application models and Industrial upate interactive application in industrial environments, and provides the possibility for enterprises to build a unified wireless network.
1) Established a comprehensive test and test system architecture and standards, and creatively developed industry unified new technology test and test standards to solve the current problem of inconsistency of various technologies;
2) Combine 5G technology with current AR, machine vision, AGV and other new technology hotspots to provide modular, flexible, and customized test scenarios;
3) To make manufacturing enterprises get rid of the chaotic application of wireless network technology in the past, which has a positive significance for promoting the implementation of Industrial Internet and the deepening transformation of intelligent manufacturing.

2.2. Test platform architecture

![Figure 1 Schematic diagram of the 5G + MEC Industrial Internet test platform architecture](image)

The 5G + MEC Industrial Internet test platform simulates the production process of home appliances, integrates industrial robots, digital twins, intelligent order management, RFID and other Internet of Things technologies, and builds an unmanned production line where users participate in the entire process, The test platform architecture is illustrated in Figure 1, which realizes the integration of IT/OT and the interconnection of whole process data through the application of technology. The test platform combines 5G technology with more than 20 scenarios such as smart logistics, machine vision, and video surveillance for application testing, some test items are listed in Figure 2.

![Figure 2 5G + MEC Industrial Internet test platform 5G application test](image)

2.3. Test platform openness

The design of the system plan considers the diversity of the 5G + Industrial Internet scene in the later period and the current market situation of the 5G terminal module. CPE is used as the terminal for the scene equipment to access the 5G network. The newly added equipment can be accessed at any time and easily, and the access to new services and new scenarios has little impact on the overall network. At present, the MEC platform supports multiple operating systems such as WIN7 / Linux, and software / APP can be deployed on the virtual machine of the MEC platform to interact with terminal hardware and software devices in real time to achieve rich system integration functions.
3. KEY TECHNOLOGY OF 5G + MEC TEST PLATFORM

The test platform is based on 5G + MEC edge computing power as the network foundation, and AR and machine vision are selected as the main upper-layer applications to form an end-to-end overall solution, the architecture is shown in Figure 3. 5G + MEC uses a total of 6 servers, 3 UPF + 1 MEP + 2 application servers, to build a "virtual private network" for enterprises, to achieve end-to-end cloud collaboration, high data security, but also to ensure that all applications High reliability and low latency requirements.

1) Through the local distribution function of MEC and the addition of a separate APN, it is technically realized that all production data cannot be offloaded in the factory within the factory to ensure data security.

2) The 5G MEC server provides flexible computing capabilities for the factory. The production application APP can directly call MEC's strong computing and AI capabilities through the MEP platform to meet its requirements for hardware servers according to different business needs, thus replacing the local server.

3) Since the MEC is very close to the terminal or information source, the time delay for the network to respond to user requests is greatly reduced, meeting the requirements of various innovative applications for low delay and large bandwidth.

4) MEC closes the internal production data of the enterprise in the local park to avoid transmission to the public network, which will cause network congestion on the transmission network and the core network.

5) The MEC at the edge of the network can obtain real-time network data such as base station ID, available bandwidth, and information related to the user's location, provide network development capabilities for various production applications, and greatly improve the user's service quality experience.

In this project, 5G provides a wireless connection service that is 3 times the coverage of the existing WIFI. In contrast, the interference monitoring granularity of 5G is 25 times that of WiFi, and there is no co-channel interference problem when connecting multiple devices. The switching delay between different base stations is less than 50ms, and zero packet loss, which solves the problem of frequent disconnection in the past WIFI connection. The two-way authentication is adopted between the terminal connected to the 5G and the network, and IPSEC, HTTPS and other protocols are used to ensure the security of the connection between the network elements during the entire data transmission process, which effectively prevents network attacks and protects the data security.

4. TEST PLATFORM 5G + MEC APPLICATION SCENARIO

Up to now, there are 25 5G application scenarios for test platform testing. Most of the test platform test verifications have been applied in the factory, which has greatly improved production efficiency and product quality. The following lists some mature application cases of 5G in Haier Internet Factory.

4.1. The application of 5G power machine vision in industrial detection

The deployment and realization of 5G network in the industrial park provides wide pipelines and high real-time transmission path, ensuring that the industrial camera, vision processor, PLC and manipulator are wirelessly connected. Realizing the automatic transformation of the entire factory, reducing enterprise costs, and providing product quality, Figure 4 shows the application of 5G + machine vision in quality inspection.
The application of 5G+ machine vision in factory

1) By covering 5G network, the machine vision system is realized to shift the fixed. The vision system unit is configured for wireless transmission, instead of the traditional wired connection method, image acquisition can be freely distributed in multiple stations, and the image processing unit is shared to realize high-speed, low-cost automated inspection production lines.

2) Based on the deployment of 5G virtual private network and Internet of Everything, the machine vision system realize the real-time remote monitoring function. Relying on the high-speed and large-connection characteristics of 5G, monitoring the MES system through mobile terminals and portable terminals without entering the workshop could be achieved, and obtain the operating status of the visual inspection system (normal operating time, effective operating time, failure reason) as well as the production reports (production quantity, Production yield rate), which is convenient for plant equipment managers and technicians to propose parameter optimization schemes for the visual inspection system (such as tolerance control, inspection key point control), and production equipment to propose rectification optimization schemes (such as production equipment operation index optimization, working environment optimization).

3) Implement intelligent visual inspection projects. Building 5G+MEC visual cloud platform, the main projects that have been implemented in the factory include cabinet appearance inspection, complete machine appearance inspection, VIP inspection and other visual inspection projects. The VIP inspection project is the leading domestic visual inspection project. Through 5G technology, the data return to MEC's machine vision inspection cloud platform and analyze the collected data.

4.2. The application of 5G empowers AR technology in factories

With the support of the 5G network, Haier has built an AR application platform covering design, inspection, maintenance, training and other manufacturing processes and industrial park security management. With the help of 5G's low latency, large bandwidth, and wide connections, AR's computing power will no longer be limited to local devices, and will be greatly migrated to the cloud, with a significant increase in computing power. At the same time, in factory applications, 5G will support AR to transmit 3D information on a large scale, meeting the urgent need for remote collaboration with low latency. In the past, the use of AR applications that are prone to vertigo will be improved, and the low latency of 5G will greatly enhance the experience of AR. Meanwhile, AR focuses on improving people's perception, cognition, and execution capabilities, and deeply integrates a new generation of information technology with manufacturing scenarios to achieve cost reduction and efficiency enhancement, and help enterprises to lean and informatize their production management.

AR platform contains the following functionalities:

1) Based on Haier's intelligent manufacturing demonstration line, it is connected to the park's 5G network to realize AR virtual product design, AR visualized management of workshops, and AR remote expert collaboration. 5G is used in AR remote collaborative maintenance and online sharing of experts. After equipment problems occur, the experts are connected to quickly deal with them, discuss key equipment issues with foreign countries, save travel expenses, save time costs, and truly realize the "zero distance communication" between on-site maintenance personnel with experts, as shown in Figure 5.
2) Based on Haier's production line, it is connected to the park's 5G network to realize AR staff operation training. Staff training consists of two parts of training content, namely system parts identification and system module organization training. AR staff operation training can improve staff training efficiency, reduce training costs, and reduce the frequency of quality problems.

3) Based on Haier Huangdao Industrial Park, the AR facial recognition service is combined with 5G to realize the internal management of Haier employees in the park. Set up the employee information management background of the park. When the park managers wear AR glasses to conduct daily inspections of the park, they can identify the relevant information of the employees in the park, or find out whether there are outsiders in the park in time, and make inquiries as soon as possible to ensure the park security management.

4.3. Security management platform based on 5G technology
In order to strengthen the safety management and control of the factory, especially the management and control of the personnel, the 5G technology is used to place the security management platform at the edge of the MEC, and the AR/Pad and other equipment are used to complete the security face recognition or time recognition for the personnel in the workshop, including Inside, outside, and unknown personnel can be found quickly, and early warning will be given to the police. In addition, it can also automatically recognize that the helmet is worn, and alarm for abnormalities, as shown in Figure 6.

5. PROGRAM INNOVATION AND QUANTITATIVE RESULTS
In terms of technological innovation, the test platform is the first domestic application of 5G+MEC platform solutions. It overcomes the problem of cloud deployment of machine vision algorithms. It uses DMZ configuration to realize the interconnection between the private network segment of the industrial camera and the MEC network segment, connecting 67 categories algorithms go to the cloud, reducing the cost of the local client application and lightweight equipment. Ecologically, the upstream and downstream enterprises of the 5G industry will be combined to develop general solutions for the industry, combining 5G and Industrial Internet scenarios, and implementing practical applications. Establish new technology test standards and technical architecture based on the model, and provide modular and customized "smart + 5G" test scenarios.

Taking the application of 5G+MEC+machine vision as an example, the ground application of the factory has reduced the investment in industrial computer, the detection algorithm is purchased on
demand, the detection result is charged, and the initial zero investment has greatly reduced the equipment investment; the technology application cycle is saved from the original 34.5 days by 1.3 days, the defect algorithm update can be completed in one day, and there is no need to stop production and replace cables. At the same time, the detection data can be shared in real time, 20 data islands are formed into a cloud platform, and the efficiency of rejecting defective products has been greatly improved.

6. CONCLUSION
The 5G+MEC Industrial Internet test platform embodies the powerful advantages of 5G and technology integration, and gives play to the characteristics of flexibility and customization. The test platform is based on modularization, flexibility, and customization, and is oriented toward reproducibility and portability. It gradually expands different application fields. Currently, it has begun to deploy applications in the fields of home appliances, molds, ceramics, and chemicals. From the traditional provision of a single network capability, it gradually shifts to the direction of platform management, integrated solutions, and ecological development, and provides overall solutions to vertical industry customers.

The application scenarios of the 5G+MEC model in Haier’s factories have continued to increase, and the portability of technology modules has continued to increase. This has brought historical changes to Haier’s global strategy, and has also accelerated the development of China’s advanced manufacturing industry, promoted the deep integration of Industrial Internet, big data as well as artificial intelligence with the real economy and provided a replicable "Haier model."

REFERENCES
[1] Du Jiadong. Thoughts on the integration and application of 5G and Industrial Internet[J]. Information and Communication Technology and Policy, 2019(11):45-47.
[2] Song Xiaoshi, Yan Yan, Wang Mengyuan. Key technologies of 5G-oriented MEC system[J]. ZTE Technology, 2018, v.24; No.138(01):25-29.
[3] Zhang Jianmin, Yang Fengyi, Wu Zhouyun, et al. Multi-access edge computing (MEC) and key technologies[J]. Telecommunications Science, 2019, 35(04): 160.
[4] Chen Yunbin, Wang Quan, Huang Qiang, et al. 5G MEC UPF selection and local offload technology analysis [J]. Mobile Communications, 2020(1): 48-53.