5G Use Cases for Vertical China

2021

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Founded in 1957, the China Academy of Information and Communications Technology (hereinafter referred to as CAICT) is a scientific research institute directly under the Ministry of Industry and Information Technology (MIIT) of China. It cherishes the cultural philosophy of "boosting prosperity with virtues and expertise" for years while adhering to the development positioning of "a specialized think-tank for the government and an innovation and development platform for the industry". Committed to "the think-tank and enabler for innovation and development in an information society", CAICT has provided strong support for major strategies, plans, policies, standards, tests and certification for the development of the national ICT sector and the IT application, thus proving itself an important facilitator in the leapfrog development and innovation of China's information and communications sector. It has been granted hundreds of scientific and technological awards at both national and provincial levels.

In recent years, with a view to adapting to the new eco-social backdrop and requirements, CAICT has strengthened its efforts in innovation to achieve wider and deeper research landscape. It has conducted in-depth research and foresighted planning in the fields of 4G/5G, industrial Internet, smart manufacturing, mobile Internet, Internet of Things (IoT), Internet of Vehicles (IoV), cloud computing, big data, blockchain, artificial intelligence (AI), future networks, virtual reality/ augmented reality (VR/AR), intelligent hardware, and cyber and information security. This enables CAICT to play an important role in strategy and policy study, technological innovation, industrial development, and international cooperation related to the ICT sector and the integration between industrialization and informatization.

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- China Mobile
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*and other industry partners, not listed one by one here.

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Content

Foreword

A total of 142 commercial 5G networks went live in 57 countries and regions by the end of 2020, connecting nearly 230 million 5G terminals. In 2020, China achieved impressive 5G developments, with an accumulative total of approximately 720,000 base stations deployed to ensure continuous coverage of key areas, connecting to 85% of all 5G terminals globally.

These figures reflect the market's keen interests in exploring and expanding 5G applications in vertical industries. Comprehensive convergence of ICT's digital driver with operational technology is key to 5G's success in verticals, because improvements in new data-driven drivers can facilitate greater gains in productivity and capability. Overall, the upcoming decade is the most anticipated period for China's industrial Internet.

As a key driver for the development of industrial Internet, 5G is faced with new opportunities but also challenges. We are delighted to see that industry customers have been embracing 5G technologies to expedite the transformation to digital and intelligent infrastructure, while striving to better utilize connectivity and capabilities to empower their businesses. China has gained invaluable experiences and insights from extensive and comprehensive explorations to empower vertical industries with 5G.

The 5G Use Cases for Verticals China 2021, prepared jointly with Chinese operators and industry partners, is comprised of 21 outstanding examples of 5G-empowered applications for verticals, ranging from industrial manufacturing, ports/mines, transportation, electric power, healthcare, to content creation, and zooms into the practical scenarios, technical features, and development opportunities for the next generation technology, such as:

• How to build explosion-proof 5G base stations in challenging, complicated conditions such as underground coal mines

• How to use 5G live streaming to enable smart inventory management and remote control at an ocean-going container port whose cargo throughput has ranked first in the world for 11 consecutive years

• How to use private 5G network slices to ensure precision time service in grid power distribution in urban areas across five provinces that serve more than 18.2% of the national population

• How to adapt business operations to changes brought by new technologies in the Cooperative Vehicle-Infrastructure System where autonomous driving has been deployed across 60 km main bus routes and in 50 operating vehicles

• How to enable "talking" equipment, automated machine operation, and higher efficiency in a high-temperature and high-risk steel plant via 5G private network deployment

We hope that the application scenarios, lessons learnt, progress updates, and reflections in the report will inspire the journey to empower more vertical industries with 5G, in particular the upcoming large-scale 5G developments both in China and globally.

Sihan Bo Chen
Head of Greater China, GSMA

As the key technology for the next-generation information and communication sector, 5G serves to build comprehensive digital infrastructure, facilitate information development through the "main artery", and fuel the social and economic transformation. 5G has contributed to the rise of many smart devices and value-added enterprises, empowering a wide array of industries with growing penetration in verticals, and enabling digital economy that is driven by both consumer Internet and industrial Internet.

Over the past year, we have been challenged by the COVID-19 pandemic, which, however, has also expedited 5G development. Together with GSMA, in the early onset of the pandemic, the China Academy of Information and Communication Technology ("CAICT") released the Mobile Industry Response to COVID-19 in China joint report, and held seminars on related topics to drive international cooperation and global 5G development.

To step up innovation efforts for 5G applications, CAICT has worked with IMT-2020 (5G) Promotion Group and 5G Applications Industry Array to organize the "Blooming Cup" 5G Application Pitch Competition for three years in a row, which has seen wide participation from industries, businesses, and individuals. Designed to scout for and incubate innovative 5G applications and ensure quick access to the market, the event has obtained extensive support from the industry with fruitful results. Taking in a total of 4,289 entries in 2020 alone, the event has gathered quality resources from governments, enterprises, universities, research institutions, and other sectors of the society, and showcased latest developments and trends in 5G applications, and therefore offering an impetus to the full-scale commercial roll-out.

This book includes 21 excellent 5G use cases in China, including some "Blooming Cup" winners. I hope that these cases can guide and inspire those who are engaged in 5G and its applications, and spark more innovative ideas. Further efforts are needed for the development of 5G converged applications, and the CAICT is willing to collaborate with GSMA and other stakeholders to seize new opportunities in 5G industries and open a new page for the world's digital economy.

Wang Zhiqin
Vice President, CAICT

5G Smart Grid for China Southern Power Grid

The 5G smart grid project, a leading project launched by China Mobile Group, has yielded fruitful results both technologically and commercially. It is a telling example of how 5G empowers industries. 5G technology is a perfect fit for power grid business with its large bandwidth, low latency, high reliability, and safe network slicing. In 2020, CSG, China Mobile, and Huawei jointly made breakthroughs in enabling terminals with time service function and network slicing, and China Mobile Guangdong took an important step forward in shifting its focus from SIM card to network slicing centric service. By providing a wide-area sliced private network to CSG, China Mobile Guangdong has secured new business growth with government and corporate customers and set an example of 5G application in industries.

Ge Lei
Deputy General Manager of China Mobile Group Guangdong Co., Ltd.

SOLUTION PARTNERS

中国南方电网 CHINA SOUTHERN POWER GRID | 中国移动 China Mobile | HUAWEI

OVERVIEW

China Southern Power Grid Co., Ltd. (CSG), established on December 29, 2002, operates power grids in five southern provinces including Guangdong, Guangxi, Yunnan, Guizhou, and Hainan, and has connections with national or regional power grids in Vietnam, Thailand, Myanmar, and Laos. CSG has a total service area spanning 1 million km^2 and serving more than 254 million people, or 18.2% of the national population.

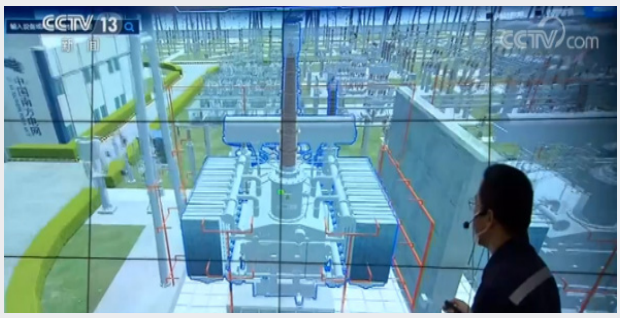
In 2018, CSG, China Mobile, and Huawei started to jointly pursue innovative application of 5G+ smart grid and have achieved breakthroughs in technologies and services. 5G has empowered a highly reliable virtual private network with security isolation for smart grid and the project achieved eight world's firsts:

8 world's firsts

1. The first "5G+ Smart Grid Whitepaper"
2. Top contributor globally of 5G industry application proposals to the 3GPP
3. The first to deploy the application of 5G+ differential protection
4. The first to deploy the application of 5G+PMU
5. The first to realize end-to-end network slicing for existing networks
6. The first 5G-based power grid CPE
7. The first pilot zone covering a full range of power related services
8. The first prize again in the Blooming Cup 5G Application Competition

The project aims to build itself into a new benchmark of 5G industry applications in terms of top-level design, international standardization, key technologies, field pilots, and service operations. The project has improved automation and inspection efficiency of power grids and saved construction costs, boosted operators' revenue, built a good industry ecosystem, and continued incubating products and models for commercial use. The three parties evaluated 53 grid application scenarios covering an extensive range of processes from power generation, transmission, transformation, distribution, and use, and started pilot services first in Guangzhou and Shenzhen for small-scale commercial use. The project is expected to be replicated in scale in five provinces of southern China in 2021.

power generation → transmission → transformation → distribution → use



CHALLENGES

A power supply system is not complicated in nature, with electricity generated at power plants, transmitted via the main network of high-voltage and high-capacity lines to distribution centers, and then distributed to end customers. A smart grid in the future is expected to satisfy the needs of massive connections, security and efficiency, and peripheral expansion. The main application scenarios include:

Power Transmission

Manual inspection for 15-20 days

AI inspection + 5G video uploading only for 2 hours

Power Transformation

Manual inspection for 3 days

AI inspection + 5G video uploading for 1 hour

Power Distribution

In power transmission, the biggest challenge lies in the grid coverage which includes both underground cables and high-voltage lines. It makes fault detection, which is mainly dependent on manual operation, very difficult and inefficient. CSG has transmission lines spanning over 300,000 kms and more than 110,000 towers. For years, CSG has been searching for high-tech solutions for long-distance operation and maintenance. For example, infrared sensor drones need to send back inspection data via communication methods. High-speed wireless transmission can greatly improve communication efficiency. As 5G technology can send back data in time at high speeds which can then be analysed by the edge cloud AI, power companies can significantly improve fault detection accuracy and O&M efficiency.

As for power transformation, common substations need to be equipped with functions like online monitoring and mobile inspection. With 5G technology, they can operate at higher efficiency and enable accurate identification of the operation and maintenance status of equipment.

The challenge facing **power distribution** is the most prominent as smart grids need to satisfy requirements of massive connections, security and efficiency, as well as peripheral expansion. The distribution network, equivalent to the access and convergence layers in the communication network, requires high construction cost, but power companies can hardly realize full coverage with fiber optic cables. The main distribution network has been fully covered with fiber, but peripheral networks are still unconnected due to their large footprint, high costs, long lead time and maintenance difficulties (RMB 150,000/km). CSG has 300,000 distribution rooms, which face great difficulties in implementing sensing and control capabilities, and in particular, real-time control due to the lack of effective communication means. CSG has done a lot of work in this respect, for example, PMU and differential protection, which are all heavily dependent on communications. 5G technology (of average latency of 10ms and time service error less than 1 μ s) can be used to minimize the fault range and quickly restore power supply to users. As a result, power distribution reliability has been greatly improved and construction costs reduced.

The meter reading **in the process of power usage** is also troublesome as CSG has more than 90 million users. With future demand for interactive distributed energy access that cannot be supported with 4G technology, we need to rely on 5G to create additional values for users.

SOLUTION AND VALUE

01 Project Value and Impact

5G and AI have provided a safe and flexible virtual private network for power grids, a great help for CSG to carry out its digital transformation strategy. With high-precision time service and low latency, 5G technology has realized differential protection for distribution networks and brought down construction costs by 50%. In transmission and transformation scenarios, a combination of 5G and AI has enabled smart inspection and increased work efficiency by 80 times. 5G also enables security isolation of power grids with end-to-end network slicing and chip encryption technology.

A small-scale commerical network has been deployed in Guangzhou and Shenzhen, and is expected to be commercially available more widely in five provinces of southern China to serve over 10 million end users and generate social and economic benefits of at least RMB 5 billion. In the future, 5G technology will be applied to other scenarios and power terminals at scales of tens of millions and even hundreds of millions of users. In this way, the duration of power failure can be shortened, power supply efficiency can be improved, and the cost of electricity consumption can be reduced, and which will also in turn minimise losses to society and economy, and save operating costs.

02 Commercial Value

The power grid is everywhere and operators need to provide a wide-area virtual private network. The project defines the standards of network slicing service. By far, CSG, China Mobile, and Huawei have designed the top-level structure of slicing network in the five southern provinces, and identified billing modes of private slicing and general slicing based on different service levels. The practice can be replicated in other industries.

03 Innovations

Define application criteria

Published "5G+ Smart Grid Whitepaper" and "5G+ Smart Grid Demand Whitepaper";

Define top-level structure

Published "5G+ Smart Grid Top-level Structure" and realized commercial use of grid slice. At the network level, standard slicing models have been identified according to the safety categories of power grid services. China Mobile Guangdong has commercialized power grid products in NSMF+ and CSMF+, and CSG has achieved independent operation and management at the grid slice management platform.

Define industry technology standards

More than 20 proposals regarding 5G+ smart grid have been submitted to the 3GPP to determine time service and slicing standards; the air interface time service accuracy is required to be reduced down to 1μs. The project carried out targeted developments on networking, equipment, and terminals, and achieved a field-tested average latency of 10ms. From the clock source at the base station to the terminal, the air interface time service accuracy could be reduced down to 300ns.

Define safety standards

Built a comprehensive safety protection system for 5G smart grids, with slicing + MEC + terminal safety chips + situation awareness. Published "5G Network Security Whitepaper".

Define new service model

Created the innovative business model of wide-area slicing private network.

First power CPE terminal

A CPE terminal with time service function has been created according to power grid time service requirements and applied in Guangzhou and Shenzhen at a small-scale trial.

REFLECTION

5G technology is key to digital transformation of CSG. After nearly three years of joint research on every application scenario, the joint project team of CSG, China Mobile, and Huawei has identified specific network requirements and parameters in business scenarios, and in particular, resource allocation and performance of network slicing that can support commercial power grid services. The small-scale trials in transmission, transformation, distribution, and use scenarios have demonstrated that 5G network can better satisfy the security, reliability, and flexibility requirements of power grid services while improving production efficiency and reducing O&M cost.

Leveraging the national "new infrastructure" initiative, CSG, China Mobile, and Huawei will continue to advance CSG's digital transformation of CSG through 5G, AI, and cloud technology. The three parties will work together to build a pilot zone for 5G+ digital power grid in Nansha and Shenzhen and promote the practice in five southern provinces. From technological verification to scale application, the three will work to create a booming 5G+ digital ecosystem.

China Telecom: 5G + MEC Smart Business Digital Twin Platform

Commercial complex, a new modern urban business form, is not only a typical gathering place of urban citizens and modern retail forms, but also of significance for keeping the domestic economic cycle smooth and promoting new information consumption and 5G consumer applications. China Telecom has been proactive in online-offline channel innovation, including the transformation of stores, operations, and sales. It speeds up the establishment of a marketing service channel system that revolves around customers and features online-offline integration, digitalization, and ecosystem. In 2020, China Telecom took the lead to release the 5G + MEC smart business digital twin platform. In 2021, we launched a cooperation plan to develop 5G + MEC smart applications in 1,000 commercial complexes, as part of our efforts to create new digital marketing scenarios and empower one-stop conversion of traffic. China Telecom is willing to innovate actively with all industry peers, share the value of channels, build a 5G ecosystem, and bring smart living ideas to life.

Guo Yong
General Manager of Omni-channel Operations Center, China Telecom Corporation Limited

SOLUTION PARTNERS

OVERVIEW

The COVID-19 pandemic in 2020 has dealt a heavy blow to the traditional commercial economy, which translated to the accelerated digital transformation among commercial complexes. It has become a consensus industry-wide to reconstruct business scenarios and create a new information consumption model that features online-offline integration. China Telecom took the lead in building China's first 5G + MEC smart business digital twin platform, offering a new 5G-based infrastructure to support the digital transformation of traditional commerce. The platform is built on China Telecom's world-leading cloud-edge collaborative 5G SA network and empowered by core technologies such as high-precision point cloud maps and 3D reconstruction. Relying on China Telecom's independently developed edge computing platform, the 5G + MEC platform helps bring user-side application capabilities to edge nodes near the commercial complexes, to ensure low latency, high bandwidth, and cloud rendering-level computing power. The platform is now connected to more than 100 leading commercial complexes, commercial pedestrian malls and free-trade zones such as Hefei MixC, Beijing Xidan Joy City, Shanghai Super Brand Mall, Guangzhou Grandview Mall, Suzhou Wuyue Plaza, Hangzhou Intime Department Store, Chengdu Kuan Alley and Zhai Alley Commercial Street, and Fuzhou Suning Square, benefiting more than 20,000 retailers. It has helped the traditional commerce accelerate the construction and digital transformation of new infrastructures, supporting merchants to leverage and expand online-offline integrated information consumption models, and promoting foot traffic recovery and consumption recovery.

CHALLENGES

On the one hand, the COVID-19 pandemic has resulted in sharp cuts in foot traffic and revenue of commercial complexes and commercial pedestrian streets. How to increase the traffic and sales conversion rates to improve revenue while carrying out pandemic prevention and control measures has become a top priority. On the other hand, in view of the consumption upgrade, integrating cultural and emotional elements, social experience, and real-life scenarios into consumption has become a key to reconnecting consumers and business. Commercial complexes, which connect business parties to consumers, are speeding up omni-digital integration and innovation. They utilize new technologies to boost digital interactions, diversify consumption scenarios, improve service quality, and interact with users in depth to form an emotional resonance and encourage social sharing, with the goal of improving user satisfaction and the efficiency of refined customer operation continuously. However, many challenges remain. For example, most commercial complexes lack a digital operation platform, leading to isolated merchant data and poor customer management and precision marketing. Besides, they don't have online-offline integrated shopping scenarios that young customers need, with few means to manage private traffic. Some other

commercial complexes have a large, yet underutilized physical space, with insufficient immersive scenarios, leading to a poor marketing experience, slow iterations, and low conversion rates.

The construction and application of 5G + MEC smart commercial complex have shown that 5G technology is needed to solve these key challenges. China Telecom joined hands with leading commercial complexes to develop gigabit-class 5G, broadband, and Wi-Fi networks, which can significantly improve the underlying connection and build a "digital twin parallel world" for commercial complexes.

China Telecom has deployed a series of 5G applications in the virtual reality field such as 5G cloud XR digital landscape, 5G cloud XR virtual shopping guide, 5G cloud XR red packet hunt, 5G cloud XR entertainment space, 5G AI virtual person livestreaming, and 5G + AI big data analysis. This has created new scenarios to serve traffic attraction and shopping guide as well as digital marketing, which has boosted the digitalization of people, products, and places in traditional commerce while creating a new immersive and entertaining shopping experience for consumers.

SOLUTION AND VALUE

01 5G digital twin space

The 5G + MEC smart business digital twin platform collects and reconstructs the digital twin base in offline commercial scenarios such as commercial complexes. It parses and reprograms the real-world, establishes a digital twin mapping of the physical space, and creates an interesting shopping, consumption, social networking, and interactive entertainment experience. Consumers can use XR interactive terminals such as mobile phones, tablet apps, mini programs and AR glasses to visit the virtual-real integrated parallel world of interactive commercial entertainment in a real-world scenario. This platform forms a closed loop of membership privileges, brand marketing and business operations and enables game-like operations of offline business activities through the XR intelligent engine.

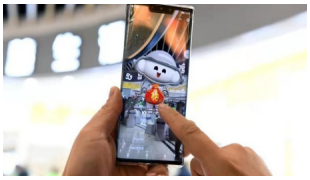
The platform is based on the MEC platform independently developed by China Telecom and offers "message forwarding service" and "positioning service" on e Cloud. Relying on edge computing for cloud-network collaboration, the platform secures low latency, high bandwidth, and high computing power as well as a diversity of AR, VR, and MR applications. In the application architecture design, XR cloud rendering, cloud games and other contents are deployed on the MEC based on cloud-edge collaboration, so as to ensure reliable connections while reducing latency and jitter. For commercial complex operators, the platform provides centimeter-level positioning and hour-level scaled deployment of large spaces and customized scenarios. For customers, it provides immersive, high-precision, high-fidelity, and large-scale mixed reality applications, with latency reduced from 50 ms to 10-20 ms. The platform is the first in the industry to commercialize 5G + MEC scenarios in the public market. China Telecom adopts a five-step method for quick deployment, namely deployment on network + in edge server room, cloudization of commercial complexes and merchants as a whole, collection by a digital twin point cloud map, 5G cloud XR customized modeling and editing, and implementation of various 5G cloud XR applications. This method guarantees that digital twin modeling, platform connection and implementation, and customized scenario deployment of a new commercial complex can be completed within one week.

In a 5G digital twin space for commercial complexes, virtual landscape and props are arranged in a point cloud map, and the content can be easily published.

02 5G-based cloud XR digital marketing

5G-based cloud XR digital marketing includes 5G-based cloud XR digital landscape, 5G-based cloud XR navigation and guide, 5G-based cloud XR red packet hunt, 5G + AI smart parking, and 5G-based UHD cloud livestreaming, with the goal of creating a smart solution covering everything from "attraction" to "stay" and further to "post-shopping touchpoint" which revolves around the retailing scenarios of commercial complexes, and provide consumers with a refreshing shopping experience. The 5G + AI smart parking system helps customers park and find cars through 3D scanning and modeling and intelligent vehicle identification. This solution addresses the pain points of parking lot management, and enables targeted membership service pushes by using big data analysis. When consumers approach the mall, real-time card about the food, parking, and the latest membership privileges will be pushed to them. China Telecom's 5G Future Mascot helps take consumers through the time gate into the XR digital twin parallel world . Customers can open the AR navigation and guide, and browse the brand video advertisements and ratings of thousands of shops along the street. Or they can scan the QR code of a merchant to exert their AR treasure hunting skills in search of big awards and AR red packets. Besides, they can also take photos with AR virtual landscapes of the Chinese culture, the universe and starry sky, the underwater world, or the art gallery. After leaving the mall, consumers can follow the service accounts of merchants to stay updated with the latest discounts and promotions and stay connected. Users can

also attend a music festival or an art week on cloud empowered by the 5G-based cloud VR UHD technology at home, allowing users to experience a wonderful journey of mixed reality.

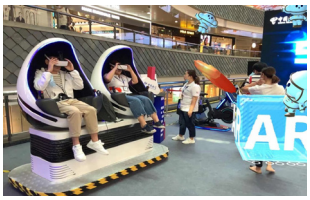



The platform creates an XR shopping experience with the complex merchants. Customers can browse 5G-based AR video advertisements and comments and click on AR red packets to win coupons.


The platform creates a 5G-based digital landscape for the complex atrium during holidays and by using themed marketing activities, building an Internet-famous place for the young.

03 5G-based cloud XR entertainment space

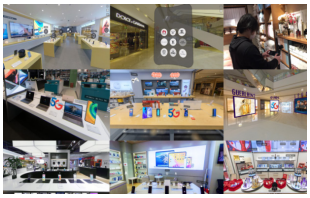
In the 5G-based cloud XR entertainment space which brings together a variety of popular 5G-based cloud VR games such as time machine, car racing, and flying theaters, consumers all want to experience the immersive and sensory applications developed based on the 5G XR technology. They can interact and dance with AI idols, record exciting short videos in real time and make them into video ringtones. There are also customized video ringtones for commercial complexes to suit the specific needs of complex operators and retailers.

5G cloud XR entertainment space achieves a new milestone of digital entertainment in traditional commerce.

04 5G-based cloud XR virtual shopping guide

With the 5G-based cloud XR panoramic virtual shopping guide for retailers, users can enjoy an immersive shopping experience with on-cloud shelves, windows, and shopping tours among others anytime and anywhere, as long as they have their mobile phones with them. They can also interact with their favorite products, and click to check the real-time prices of virtual products, limited-time discounts, membership privileges, etc., completing online ordering and shopping in a relaxing, natural, and entertaining environment.

5G-based cloud XR virtual shopping guide boosts online-offline integrated consumption.

REFLECTION

In the practices and scaled promotions of the platform, the traditional commerce leverages the digital twin space as a way to bring online-traffic, and merchants can convert offline traffic to revenue. Through digital activities based on 5G XR applications, digital communication activities such as 5G UHD livestreaming, and digital marketing such as big data + AI, a new B+B2b2C ecosystem and business model of "business operators + China Telecom to merchants to customers" has been established, structuring an integrated conversion process to secure long-term returns.

Here are three typical cases. In the cultural tourism industry, Chengdu's Kuan Alley and Zhai Alley Commercial Street has created a 5G-based XR panoramic view. The average daily number of visitors to panoramic stores has exceeded 10,000, and the foot traffic of the area has increased by 33%. The area was named a national demonstration pedestrian street by the Ministry of Commerce. In the trade industry, the platform has created a new immersive shopping experience for duty-free products in hotels of Hainan Free Trade Zone, which has cut the operating cost of CDF Mall by nearly 15% while increasing hotel room prices by nearly 50%. In the commercial real estate industry, Hefei MixC has built the first 5G + MEC smart commercial complex in China, fully upgrading its digital customer attraction and immersive entertainment consumption experiences. Thanks to this, the complex's foot traffic has increased by 15%, and the turnover of more than 100 merchants has increased by 30%. The above technical standards and application scenarios have been included into the "5G + Five-star Shopping Center Industry White Paper" released by the 5G Applications Industry Array in 2020, and are accelerating the standardization and deep integration of 5G technologies in the commercial field.

In 2021, the platform plans to empower 1,000 commercial complexes and 100,000 retailers across China. Besides, it also strives to explore application scenarios in digital retailing, incorporate commercial operations and marketing processes, and accelerate online-offline integrated information consumption expansion and upgrading.

5G Smart Mining of Shanxi Huayong Group

The downhole application of the 5G technology ensures accurate, comprehensive and clear access to production safety data and environmental videos underground, laying a foundation for increasing efficiency and minimizing the number of underground workers as well as ensuring production safety in the mines.

Yu Beijian
Deputy General Manager of Huayang Group

SOLUTION PARTNERS

OVERVIEW

Xinyuan Coal Mine is affiliated with Huayang Group, with an annual output of 2.7 million tons of coal and 713 million tons of recoverable reserves. Huayang Group has been embracing 5G applications since the advent of this technology in its efforts to jointly explore intelligent, 5G-empowered coal industry development, so as to effect a change in the company's production efficiency and capacity and improve its profitability as well. Besides, setting up a pilot industry benchmark can also fuel the upgrading of coal mining equipment in the future.

On May 25, 2019, Huayang Group and China National Coal Association organized experts from various parties for a seminar on the application of 5G in mines, and launched the project. On September 5, 2019, Huayang Group, China Mobile, and Huawei established the 5G Communication Coal Industrial Application Innovation Alliance, marking that the project has entered the substantive advancement stage. On November 18, 2019, China's first downhole test of 5G base station was carried out, with the downhole coverage by a single base station reaching 400 meters. On April 29, 2020, Huayang Group, together with China Mobile Shanxi Co Ltd., Shanghai Shsany, and Huawei jointly obtained China's first 5G base station coal mining product safety certificate in China Coal Technology & Engineering Group Corp (CCTEG) in Changzhou, Jiangsu, China. On June 18, 2020, the 5G Smart Mine Alliance was established. Lin Wu, governor of Shanxi province, announced the establishment of China's first 5G-based coal mine in Shanxi Huayang Group Xinyuan Company.

Xinyuan Coal Mine is currently cooperating with China Mobile Shanxi Co. Ltd. to use explosion-proof base station equipment with safety certificate for coal mining products. 14 RRUs have been deployed in the first phase, and 64 RRUs are planned in the second phase. MEC/UPF was also deployed at Xinyuan Coal Mine to ensure mine data safety and prevent data leakage.

CHALLENGES

Production safety

Production safety is the top concern of coal companies. The problems of high level of methane and coal dust, water hazards, and inundations in the downhole production environment, as well as the long working hours and high labor intensity of employees (three shifts in 24 hours) have plagued coal companies. How can they utilize mobile communication technologies to improve the labor and production environment?

Restricted production monitoring capability

The traditional underground industrial ring network has limited bandwidth, and only a few videos can be uploaded to the traditional underground monitoring system via a wired connection. However, that would be like "a drop in the bucket" for operations with only a few underground workers or even unmanned underground operations which need a massive amount of videos to be uploaded. In addition, at a fully-mechanized mining face, since the coal cutters, electrohydraulic supports, and scraper conveyors are always in motion, the traditional wired optical fibers are often twisted off. How can coal companies ensure smooth video surveillance to meet production requirements?

Too many manual routine inspections

In order to monitor changes in roadway pressure, coal mines usually install a large number of pressure monitoring sensors. Now the measurements are read manually, which is not efficient and time-consuming. How can meter readings be recorded automatically? In addition, the machinery and equipment in the coal mine are all equipped with several or a dozen sensors each, and data transmission has a high requirement on network connection.

A lot of siloed networks

Previously, networks of multiple standards have been set up to meet the needs of different underground production systems. How to meet different business needs on a unified 5G network while limiting the data access within the site to ensure data safety is also a challenge.

SOLUTION AND VALUE

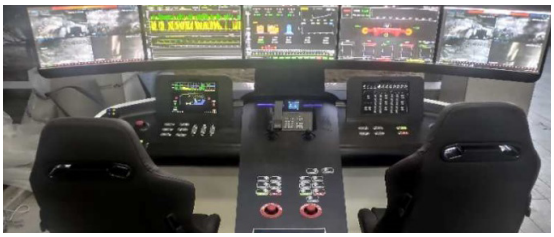
Based on a unified 5G network, the project is currently working on the following four aspects:

5G-based inspections

The chamber inspection robots are connected on a 5G network to transmit inspection data, videos, and audio signals to the overground monitoring command center, which achieves unmanned inspection of the Xinyuan Coal Mine underground substations.

Unmanned operations at the fully-mechanized mining face

There are 60 transmission channels for 4K HD videos to support the large bandwidth of gigabit-plus uplink for transmitting massive amounts of 4K HD videos.



Unmanned operations at the tunneling face

Leveraging the high reliability, high bandwidth, and low latency of the 5G network, the project implements overground remote control of the underground equipment to minimize the number of the tunneling staff.

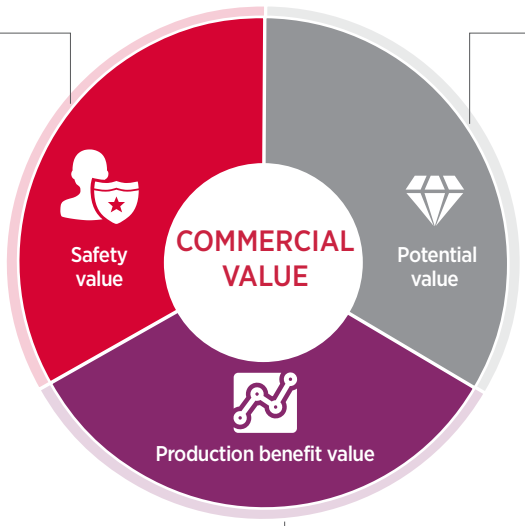
Data collection

The project utilizes the NB IoT network for mining to wirelessly return collected information such as hydrology and gas data, easing the transmission and maintenance process.

In view of the stringent environment requirements of the coal mining industry for production safety, the project team has been focusing on the following three aspects:

Customize 5G base stations for mining	Release a gigabit-class uplink feature	Quickly launch 5G terminals for mining
In response to the explosion-proof requirements for underground coal mines, the team cooperated with industry partners to build the world's first 5G-empowered mining base station;	The demand for transmitting a massive amount of videos in underground coal mines is totally different from the traditional personal mobile network demand which is dominated by downloads. A larger amount of uploads are required for underground mining. Huawei initiated a 1:3 ratio (DL:UL) to support gigabit-class uploads to meet the needs of underground video transmission. The larger uploading bandwidth has become a required option for 5G-based coal mines, and will be included into the 5G smart coal mine standards. Core Network was deployed in the "kite mode", when the connection between Operator's public network and enterprise's private network is disconnected, the enterprise's private network can still work properly. This can address the network reliability needs of the mine enterprises	The team joined hands with industry partners to quickly launch underground 4K cameras, mobile terminals, explosion-proof CPE, 5G general modules, edge gateways, and sensors based on the 5G network.

The project can help minimize the number of underground workers, reduce labor intensity, reduce the "three violations" (violations of command rules, work regulations, and labor discipline), reduce accident rate, and prevent major accidents. Project evaluation: The number of underground workers can be reduced by 20 per shift.



The underground 5G sub-meter positioning is under development. Once the technology is applied, it can save more than RMB 6 million of investment in precision positioning system.In the 5G ring network test, the newly built 10-gigabit ring network will be replaced, saving more than RMB 5 million of investment.

The project enables intelligent fully-mechanized coal mining, minimizing the number of underground workers, increasing efficiency, and cutting cost about RMB 2.5 million/year.

5G Internet of things, predictive protection, and production efficiency improvement about RMB 3 million/year.

Video + AI for real-time monitoring of equipment operating status, with the equipment failure rate reduced by 15%, saving RMB 2 million/year.

The project implements 5G-based intelligent tunnelling to cut personnel cost by about RMB 150,000/year.

The project implements unmanned inspections to reduce the staff size and the personnel cost about RMB 1.2 million/year.

REFLECTION

Next, the project team will continue to work on the following areas according to the actual production environment and needs: 1) Terminal side: Get a coal mining product safety certificate for the scheme of the underground mobile equipment charging station; add camera self-clean function suitable for underground scenarios; improve the design of coal cutters and tunnel borers that contain a large number of metal modules to integrate 5G modules. 2) Network side: Improve the 5G network and signal coverage in the event of uneven roadways. 3) Cloud/App: In view of the company's requirements of keeping data strictly within the site, find a better way to build a flexible application platform locally that can accelerate the introduction of new applications in 5G scenarios. 4) Operation and maintenance: In view of the company's production safety requirements and downhole personnel management systems, corporate customers have a high demand for self-operation and maintenance, especially self-operation and maintenance of underground equipment. Find a better way to improve the visualization and remote management of self-service equipment.

The launch of the first 5G-based coal mine has strengthened our determination of advancing 5G-accelerated comprehensive energy reform, strengthened companies' confidence in using 5G technologies, and showcased the industry's perseverance in 5G innovation. As a typical case of "new driver for the new-type development of China's economy", the mine has changed the social impression on the traditional working environment of coal mine employees who can now remotely mine coal in a comfortable overground operation center, transforming from the black-collar to the white-collar.

Looking to the future, we will build up a 5G-based network to pool together the comprehensive advantages of cloud computing, AI, and industry applications. Various parties will continue to explore unmanned driving, AR operation and maintenance, and precise positioning among other areas and expand business from underground coal production to overground coal washing, coal preparation, coal transportation and other fields. This way, we can ultimately build a standard system of 5G+ smart mines and further promote the intelligent development of the coal industry.

Pangpangta 5G+ Smart Mining

In order to technically ensure underground explosion-proof safety, 5G network are deployed at scale in the coal mine which puts an end to the challenges faced by traditional network technologies. The solutions meets the requirements in highly risky, harsh, mobile production and production site environments that are changing and stretch long, with a large number of devices and sensors as well as workers. This project records four firsts in the energy industry. To be specific, it is the first underground network with 5G equipment officially passing the national coal mining product safety certification, the first underground network deployed at scale, the first network with its official commercial contract signed, and the first network that supports 5G applications. These achievements are attributable to the joint efforts made by all the staff members.

Li Yi
General Manager of China Unicom

SOLUTION PARTNERS 霍州煤电集团有限责任公司 HUOZHOU COAL ELECTRICITY GROUP CO., LTD. | China unicom中国联通 | 富华宇祺 FUHUAYUQI | HUAWEI | ZTE中兴

OVERVIEW

The smart mining project undertaken by Pangpangta Coal Mine in Lvliang, Shanxi was launched in July 2020, and the first phase of the project passed the acceptance in mid-October.

In terms of networking, the project has set up a high-quality industrial internetwork integrating underground 5G+ 10-gigabit-class industrial ring networks, and established 10 underground ring network nodes in the north and south areas of the mine. With 144 base stations covering more than 100 km of roadways and 48 scenarios, the project has set up an IPRAN industrial ring network for mining and 5G base stations that support 50,000 gigabits per node in the south and north areas of the coal mine. The network has 400,000 gigabits of bandwidth in total, and its 5G slicing technology enables physical channel isolation. The ring network is deployed using disaster-resistant optical cables to achieve centralized management in one network. Meanwhile, the 5G slicing technology is used to ensure stable and private transmission of data from different systems in one network. The underground backbone network can not only meet the needs of underground mobile communication, but also provide the communication protocol interfaces required by the underground industrial ring network. Based on the multimodal base station equipment with explosion-proof certification, the solution achieves active coverage of 4G, 5G, and NB-IoT networks in the mine. The conventional communication service area is covered by the 4G network, and working faces and tunneling faces among other sites that require high bandwidth and low latency are covered by the 5G network. This has laid an important network foundation for promoting smart mining construction.

In terms of application, the solution adds intelligence to the coal mining systems based on the high-quality 5G+ networks and the edge computing platform. It supports intelligent applications including AI intelligent belt sensing, NB+ full situational awareness, multimedia communication scheduling, high-definition video collection, intelligent video analysis, and remote control to achieve intelligent and interconnected management of all production elements in the mine, such as people, machine, material, and environment. This further makes it possible to promote the solution to a diversity of scenarios such as underground communication, material management, safety monitoring, centralized control, and intelligent production tools.

CHALLENGES

In traditional coal production, safety issues such as mine disasters frequently occur, labor costs are high, and mining operations are difficult and dangerous. The government and enterprises hoped to use digital technologies to promote the construction of intelligent mines and reduce or even eliminate manual underground operations.

In recent years, many major mining groups proposed to intelligentize coal mining. As coal mine production embraces a higher level of intelligence, high-definition video transmission system, high-density sensor access system, intelligent robot inspection system, and intelligent coordination and control system jointly form an equipment group, which requires unified and coordinated management through a central control system for rapid feedback control. The massive amount of data collection, transmission, and connected devices, and the extremely low-latency control operations all post unprecedented requirements on the quality and capacity of network transmission. High-bandwidth, low-latency, and highly reliable wireless transmission networks have become an important link toward intelligent coal mining.

SOLUTION AND VALUE

Network is the foundation of intelligent mine construction. At present, the industry uses optical fibers and industrial Ethernet to build a ring network for data transmission. Wi-Fi is used for most wireless connections, and some demonstration mines have 4G networks. However, the underground environment is complex, and the industrial ring network with optical fibers as the main transmission medium can be difficult to maintain and prone to damage. 4G networks are unable to effectively support the data transmission of various control models that are demanding on network latency. Wi-Fi connection has a significant delay in data transmission across access points (AP).

Many problems have indicated that the existing underground network has severely restricted the development of intelligent mines. Relying on new technologies such as 5G and IPRAN, it is necessary to build a highly reliable network to reduce underground communication delays, increase transmission bandwidth, and enhance support for mobile operations, so that the production statuses on site can be learned in time to identify risk factors and control operation processes. Explosion-proof equipment has become a main technical challenge for underground 5G network construction. This project focuses on innovation in the following aspects:

01 Create a highly reliable underground network for coal mines

Through the underground 5G equipment installation and testing, the project has recorded a measured uplink speed of 200 Mbps, a delay of less than 20 ms, and an effective coverage radius of 300 meters in radius. The underground 5G coverage pattern has been understood, and the overall intelligent mine network is designed based on the measured data. The overall construction idea is:

- Use flame-retardant and impact-resistant optical fiber cables to form a safe and reliable underlying network;
- Introduce the IPRAN technology to build an underground telecom-level 10-gigabit ring network;
- Realize full 4G coverage underground and provide communication at any location and imperceptible switches between base stations;
- Cover key application scenarios with 5G signals to support applications such as the transmission of the fully-mechanized mining face information from multiple data sources and high-definition video of the tunneling face

to meet all the requirements of intelligent mines for the underlying network and achieve intelligent management and operation in "one network". Based on the IPRAN ring network and 5G wireless network, Pangpangta Coal Mine researched to apply the new techonologies to multiple scenarios of underground production. The research revolved around six aspects:

1. Leverage the high bandwidth of 5G networks to enhance the quality of underground video surveillance and transmit high-definition industrial videos and images of roadways, chambers, and working faces in real time.
2. Detect violations in key scenarios based on the intelligent analysis of high-definition videos to automatically identify violations and send warnings.
3. Make use of the NB-IoT technology to enable wireless operations of sensors in an environment without any power cords or network cables, to enhance the data collection and network awareness capabilities of various coal mine scenarios.
4. Based on 5G, use the AR/VR technology to remotely connect underground workers with experts to help improve remote equipment maintenance.
5. Give full play to the low latency feature of 5G networks to support remote control and unattended operations of substations, pumping stations, and gas drainage works among other places.
6. Based on the full coverage of 5G wireless signals, achieve robot-aided inspections of hazardous areas to remotely collect data about the temperature, gas content, and equipment statuses in a timely and comprehensive manner.

02 Build a core platform for edge computing

As a key technical support for intelligent construction, the solution can analyze specific events and data in coal mining in locations closer to where the analysis results are needed, and controls mining equipment to make quick and accurate responses. The core cloud is equipped with an intelligent platform which gathers mining data and edge cloud analysis results. This can enhance the edge cloud's ability to respond to the analysis and thereby improve the flexibility, operating efficiency and intelligence level of the entire system.

03 Explore breakthrough points of applications in the 5G environment revolving around a high-performance transmission network

Following a cloud-connectivity-edge-terminal structure, comprehensive technical research and application deployment are carried out, with focuses laid on gas content monitoring, intelligent video transmission and analysis, and major equipment failure prediction among other systems to meet coal mining companies' requirements in full situational awareness, intelligent control, production safety and operation management.

With the underground 5G-empowered coal mine demonstration project, Huozhou Coal Power Pangpangta Coal Mine advanced industrialization pilot work and strived to increase the intelligent mine capacity to 10 million tons. The project has great economic and social values;

Economic value

Building a 5G network can help build multiple 4G, 5G, and NB networks at one time, helping companies' avoid repeated investment in building these networks. The robust network can support various wireless applications for intelligent coal mines, and hence increase the production efficiency and economic benefits, as evidenced by the production cost cut from more than RMB 300 per ton of coal to about RMB 200. Meanwhile, a wireless network can greatly reduce the number of optical fiber cables and devices in coal mines, and all new systems can use the network to transmit data to nearby nodes, which also reduces the investment in new systems.

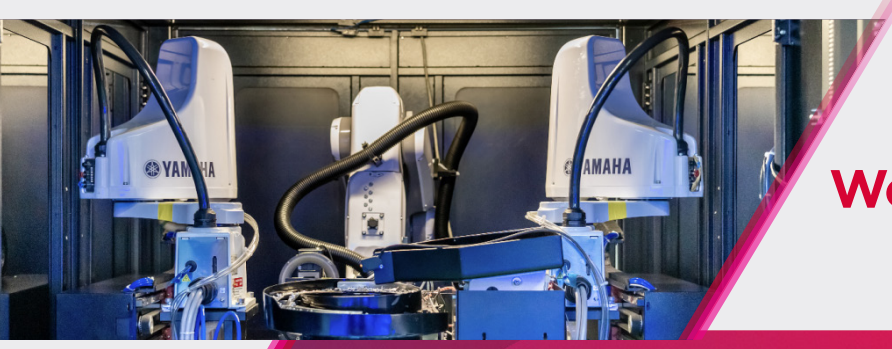
Social value

From the companies' point of view, their mode of work has changed from 2 + 1 (two shifts, and one overhaul shift) to 2 + 0 (two shifts, with minimized overhaul work). Belt failures used to need four to five hours to locate, but now such failures can be located immediately, reducing the staff size while improving the efficiency. Specifically, the number of underground workers has been reduced by around 30%, and the number of underground workers per shift has been cut from more than 400 to more than 100. Safety can be ensured with fewer or no underground workers. From the society's point of view, with the 5G technology empowering remote intelligent operations, miners will gradually become a highly educated, high-quality, and high-income group. 5G-assisted remote, centralized intelligent control helps keep miners away from the dangerous working environments, so that their families and the society do not need to worry about their safety. Moreover, 5G can also promote the development of social productivity and help solve employment problems for technical talents in related fields.

REFLECTION

This project has built a high-quality industrial internetwork integrating underground 5G+ 10-gigabit industrial ring network, and realized centralized management in one network. Eight core intelligent applications including the coal mine edge computing platform, full situational awareness and intelligent control have been deployed.

After the first phase of the Pangpangta 5G+ smart mining project passed the acceptance, the second-phase construction has been started in succession. The goal of the second phase is to build a multi-unit, multi-chain, and multi-system intelligent mining system for the entire coal mine and coal preparation plant by the end of 2021. The system can enable digital, accurate and real-time collection, networked real-time transmission, and visualization of production factors and management information. Meanwhile, all main production processes such as mining, tunneling, transportation, communication, and dressing by washing adopt intelligent decision-making and automatic operations, so as to achieve regionalized intelligent decision-making and automatic coordinated operations for the fully-mechanized mining face and tunneling face.



Gian Technology's Quality Inspection Workshop Based on 5G and AI Technology

Originally, before the use of 5G, each machine needed its own computing power. Now, with the application of 5G, we can use the 5G network to free machines from the need for their own computing power. By centralizing computing power equipment in a computing center, we can transfer quality inspection data to the cloud over a 5G + MEC private network. Then, the data can be processed in the computing center in a unified manner. This significantly reduces the per-machine computing costs and allows 5G to truly empower the Industrial Internet.

Wu Junwen
Vice President of Jiangsu Gian Technology Co., Ltd.

SOLUTION PARTNERS Gian 精研科技 | 中国移动 China Mobile | 微亿智造 MICRO-INTELLIGENCE | ZTE中兴

OVERVIEW

2020 was the first year of large-scale 5G construction. Starting from the actual situation in the province, China Mobile Jiangsu is actively exploring 5G + Industrial Internet applications in the industrial manufacturing field. Jiangsu province has a developed manufacturing industry cluster, but it also has pain points, such as the difficulty in improving production efficiency, uneven digitalization, and the difficulty in ensuring production safety. Building on its 5G network and using smart industrial applications as its entry point, China Mobile Jiangsu has already expanded to over 200 5G industry vertical projects, which include joint explorations of 5G + Industrial Internet in 72 industries. China Mobile Communications Group Jiangsu Co., Ltd. Changzhou Branch (China Mobile Changzhou) partnered with Changzhou Micro-Intelligence Technology Co., Ltd. (Micro-Intelligence) and the ZTE Corporation to build an end-to-end 5G + AI quality inspection demonstration workshop solution which was successfully implemented in Jiangsu Gian Technology Co., Ltd.

CHALLENGES

Jiangsu Gian Technology Co., Ltd. is a professional manufacturer and solution provider of metal injection molding (MIM) products and the first listed company in the Chinese MIM industry. Its main business is to provide high-complexity, high-precision, and high-strength custom MIM core components for the consumer electronics and automotive fields. It is the largest company in this segment. The company attaches great importance to product technology R&D. The "High-performance Special Powder Material Near-net Shape Manufacturing Technology and Application" project completed by Vice President Wu Junwen won second prize of the 2019 National Technology Invention Awards. The company's products are already used by well-known consumer electronics and automobile brands in China and abroad, such as Microsoft, Fitbit, Samsung, VIVO, OPPO, Lenovo, and Honda.

In Gian Technology's actual production stage, the quality inspection work for 3C product parts requires a significant manpower investment. Customers have strict product quality requirements, and each part requires manual inspection with an industrial electron microscope, which takes 30 seconds to 1 minute. For this reason, Gian employs nearly 3,000 workers in its quality inspection workshop, accounting for 50% of all employees in the factory. This represents a monthly labor cost in excess of RMB 25 million. Throughout the manufacturing company, there are problems about industrial quality inspection, such as the unstable quality of manual inspection, difficulties in recruiting,

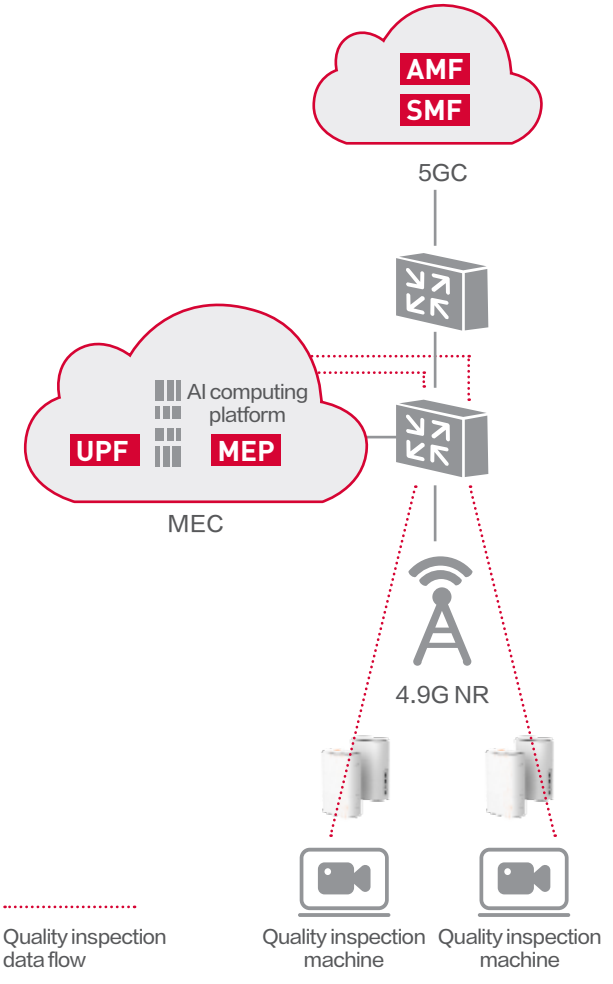
training, and retaining staff, and high costs. Especially with the COVID-19 pandemic in 2020, it is particularly difficult to recruit workers. In addition, the company is under pressure to deliver huge orders for brands such as Apple. If these orders are not delivered on time, the company will be required to pay large amounts of compensation.

For this reason, China Mobile Changzhou, Micro-Intelligence, ZTE, and other partners joined together to innovate and developed the 5G + AI Defect Detection solution. This project leverages Micro-Intelligence's technological advantages in the Chinese AI defect detection field. China Mobile Changzhou and ZTE worked together to deploy a 5G + Mobile Edge Computing (MEC) private network for Gian Technology's quality inspection workshop. The partners also worked together to develop 5G + AI quality inspection devices, build a 5G + industrial big data cloud platform, and formulate an end-to-end solution for quality inspection by manufacturers. This solution can constantly enhance productivity.

SOLUTION AND VALUE

01 End-to-End 5G + AI Quality Inspection Solution

Micro-Intelligence is a company that focuses on R&D for industrial visual quality inspection and industrial big data platforms. It is a leader in the Chinese AI quality inspection field. The Changzhou branch of China Mobile Jiangsu worked with its ecosystem partner Micro-Intelligence for an in-depth research on Gian Technology's production workshop to understand the company's quality inspection needs. This project aims to develop AI quality inspection equipment for Gian Technology by combining industrial cameras, robotic arms, programmable logic controllers (PLCs), and other components. The AI quality inspection equipment can continuously takes several HD photographs, which are transmitted to the AI computing platform for image detection. Using image recognition technology, the AI computing platform can simulate the manual surface inspection process. With machine learning and 2,000 data samples, the system can detect defects with an accuracy of 99.96% at a speed 30 times faster than manual inspection.



The quality inspection equipment feeds back multiple HD photographs to the AI computing platform. The network must provide an uplink network transmission rate of 150 to 300 Mbps depending on the number of photographs transmitted. Traditional 2.6 GHz 4G mobile networks cannot meet this requirement due to their relatively small uplink time slots. Based on the actual business needs, ZTE designed a 5G + MEC private network solution. China Mobile offers 4.9G 100 MHz spectrum resources, which are suitable for private network deployment. On the other hand, industrial private networks usually require much higher uplink rates than downlink rates. The general 2.5 ms dual-periodicity frame structure has a low proportion for uplink time slots, so it is not a good solution for this need. In response to this ultra-large uplink application scenario, ZTE developed a 4.9G base station version with a 2.5 ms single period and 3U1D time slot ratio. This greatly enhances the uplink transmission rate, with the peak rate of a single user reaching 700 Mbps, which meets the uplink rate requirements of the quality inspection equipment.

For the AI computing platform, ZTE provided an enhanced integrated MEC edge cloud solution. The edge cloud system is extended based on an NFV standard three-tier architecture. It adopts a full-stack converged architecture composed of diversified hardware, a basic platform layer , a core capability layer, and a business application layer with lightweight management feature that are heterogeneous and open. This architecture provides edge computing services in collaboration with the cloud. The edge network cloud provides computing, network, storage, acceleration, security, and other cloud computing services on edge terminals and can provide robust basic environments for network elements and Internet/IT applications, such

30times

Increase of quality inspection efficiency

30

Number of workers replaced by a single quality inspection machine

as deployment, scheduling, and runtime environments. This reduces response latency, decreases the pressure on the cloud, and cuts bandwidth costs so as to meet the diverse needs of edge application scenarios. Quality inspection photo stream data is forwarded locally without bypassing the 5G core network of the zone, ensuring the security of enterprise data. In addition, MEC provides powerful CPU and GPU computing power that can satisfy the needs of the AI computing platform.

Achievements in Phase 1 of the project: The value of intelligent upgrades is beginning to appear and more values will be unlocked in the future. After Phase 1 of the 5G + AI quality inspection system was put into operation, its commercial value gradually became apparent. First, the efficiency of quality inspection increased by a factor of nearly 30. A single quality inspection machine can replace 30 workers, greatly reducing quality inspection labor costs. It can also solve the problems of recruitment difficulties and unstable manual quality inspection. The investment cost of the entire system can be recovered in the first year, after which the system will continue to create value.

REFLECTION

The quality inspection workshop project for Gian Technology targets the pain points of manual labor and recruitment in the quality inspection processes of the MIM industry. Through in-depth integration of the emerging 5G and AI technology, it fully utilizes the high bandwidth and low latency of 5G to move the computing for AI quality inspection to the cloud, significantly reducing costs compared to standalone machines. This solution further empowers the Industrial Internet. At the same time, the 5G + AI quality inspection workshop has significantly reduced labor costs for the company, and the good input-output ratio made the company willing to sign contracts with the partners. Therefore, the project was mutually beneficial for all parties. A total of 22 quality inspection machines were put into production in Phase 1 of the project, which can replace about 600 workers in total. As a result, the investment can be recovered in the same year.

Starting from Phase 1 of the project, Micro-Intelligence conducted real-time big data analysis on the defect images produced during the quality inspection. Subsequently, they will establish correlations between the product defect data and production parameters to allow the customer to adjust various production processes. For example, the precise adjustment of mold dimensional tolerances in the injection molding process can improve mold accuracy and reduce loss. In addition, the customer can optimize and analyze process parameters such as temperature and pressure in the sintering stage to improve product yield. By training the AI on a large number of samples, the customer can further optimize the production process model. We believe that, after Phase 2 and 3 of the project, the customer will obtain even greater value from the solution.

In addition, the Zhonglou District Government of Changzhou City, China Mobile Jiangsu, and Micro-Intelligence have jointly built a 5G + industrial big data cloud platform. This platform is composed of two main parts, the "manufacturing implementation brain" and the "elastic computing platform". In the next few years, we plan to provide elastic computing capabilities to more manufacturing companies. These companies will not need to purchase any equipment or pay for subsequent maintenance and upgrades. They will only be billed for the computing resources they actually use. This will enable more SMEs to take advantage of these capabilities. At the same time, we will take advantage of the 5G technology provided by ZTE to offer quicker and more convenient elastic computing services to manufacturers. This will reduce their AI and big data costs and accelerate their digital transformations to achieve an industry-wide upgrade.

Midea Group 5G + Smart Manufacturing

As we starts a new journey, Midea Group will build an IoT platform and improve 5G-based smart industrial network solutions, so as to increase the momentum for and make greater contributions to the high-quality regional development. Since 2019, Midea has been promoting the application of 5G technology on the Industrial Internet based on the traditional network architecture. Through strategic cooperation empowered by 5G technology with operators, Midea has established 11 application scenarios and 1 laboratory and operated businesses such as data collection, modeling and data feedback, and seen significantly improved production efficiency. Through practices in multiple scenarios, Midea has worked out the application of Industrial Internet + 5G + AI in various fields including production safety, flexible manufacturing and smart logistics, which has effectively reduced the costs of production and maintenance and the cost of production line self-inspection, increased the overall operation and maintenance efficiency by 17%, and decreased the costs by 10%.

Zhang Xiaoyi
Vice President of Midea Group

SOLUTION PARTNERS Midea | 中国电信 CHINA TELECOM | HUAWEI

OVERVIEW

The 5G + smart manufacturing project is mainly carried out by the Midea Microwave & Cleaning Appliance Division (MCA). Guangdong Midea Kitchen Appliances Manufacturing Co., Ltd. (also known as the "MCA") is located in the production base in Malong. It covers an area of 500,000 square meters and a floor area of 420,000 square meters. Engaging more than 9,000 employees, it mainly produces microwave ovens, large and small ovens, and food steamers. Boasting 59 assembly lines, the division has an annual production capacity of more than 40 million pieces. In 2019, its operating revenue stood at RMB 12.9 billion.

The project is implemented to address the issues concerning the upgrading and transformation of the production lines faced by the MCA in flexible production, and is divided into three phases:

Phase 1 Jan. – Dec., 2019: Overall project design of 5G-based industrial Internet, pilot applications of 5G network in key scenarios, and preliminary development of the testing environment;

Phase 2 Jan. – Dec., 2020: Equipment purchase, deployment of 5G-based industrial Internet on production lines, development of the testing environment for 5G network, transformation into 5G-based smart equipment in typical scenarios, and plan for Internet promotion and 5G-based industrial group standards;

Phase 3 Jan. – Jul., 2021: Output of solution for 5G applications in industrial manufacturing scenarios, and promotion of 5G applications to SMEs.

CHALLENGES

1. The large demand for flexible manufacturing results in frequent adjustments to the production lines. During equipment upgrade and the improvement process for production capacity, frequent changes are made to the production lines, equipment, and logistics layout. As a result, the network deployment has to be changed accordingly, which costs more than RMB 6 million per year.
2. In production line and equipment areas where data collection is intensive, the Wi-Fi network has connection issues, especially when switching between access points (APs), resulting in slow collection and refreshing in the business system and unpleasant user experience.

Business pain points	Description of pain points
Logistics efficiency	1. AGVs suffer from severe Wi-Fi signal interference, which undermines logistics efficiency; 2. Wi-Fi connection is disconnected when roadming in the finished product warehouse, which affects scheduling information synchronization; 3. Vehicles do not support positioning and tasks cannot be dispatched to nearby vehicles.

Flexibility	1. Microwave ovens feature small batches and multiple models, making it difficult to achieve flexible production through automated production lines. There are many workers on the line, leading to a high labor cost; 2. The current KUKA robots and PLCs are based on wired networks, which is the primary challenge for the flexibility of automated production lines;
Wireless connection	1. The code scanning terminal and MES dashboard are based on a wired network, which is difficult and costly to maintain; 2. The available range of the code scanner connected through Wi-Fi is limited, and Wi-Fi connection is often interfered, resulting in data transmission failure;
Quality inspection	1. Each AI quality inspection point requires a dedicated PC or server, leading to high cost for hardware;
Operation and maintenance of production equipment	1. In the event of engineering equipment failures, equipment manufacturers cannot come to the site in a short period of time to solve the problem. It takes a long time to solve the problem, leading to prolonged impact on production; 2. The manufacturing workshop is noisy and has high temperature, with a narrow space, many complex devices, poor vision, and a large working area. Manual inspection is intensive and inefficient;
Security monitoring	1. Wiring for wired monitoring is expensive and time-consuming. Any adjustments to monitoring points require re-layout of cables, resulting in a high labor cost.

In summary, as the existing Wi-Fi network or 4G network does not support ultra-high bandwitdh and low latency, the above-mentioned business issues remain unsolved.

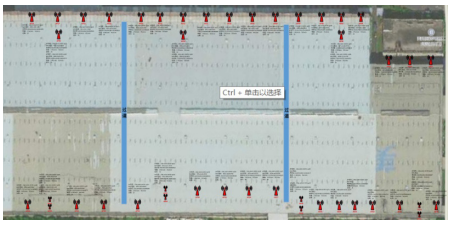
SOLUTION AND VALUE

Starting from June 2020, the project has been exploring business scenarios in the MCA production base campus, such as smart warehouse management/logistics, 5G- and cloud-based PLC, campus security monitoring, production inspection robots, 5G-based machine vision AI, 5G-based AR assistance for production line equipment, code scanner management, MES dashboard and management of production data acquisition, and has deployed 5G network in all the scenarios based on their needs to apply 5G technology in the above new industrial scenarios.

01 Smart warehouse management/logistics

1 As shelves in the finished product warehouse of Midea have five layers, high-reach forklifts are required for loading and unloading goods. There are more than 20 forklifts. Due to frequent cargo transportation, each forklift needs to sync data with the Warehouse Management System (WMS). Each forklift is equipped with a customized PC, which enables the communication between the forklift operation system and the WMS through the 5G network, to sync logistics scheduling information in real time.

2 AGV paths in the warehouse: A total of 11 Automatic Guided Vehicles (AGVs) are needed to transport goods from the injection molding workshop to the warehouse in the workshop, and from the warehouse to the entrance of the workshop. Originally, Wi-Fi network of the company was used, which requires authentication. Taking data isolation into consideration, a separate wireless LAN is deployed for each project, which is not conducive to the scheduling of AGVs in a large scope across areas. Currently, 5G network is used to support real-time synchronization of information between the AGVs and the scheduling system servers (task commands given to AGVs, control of AGV status, information feedback), which is the prerequisite for AGVs to operate in all areas.

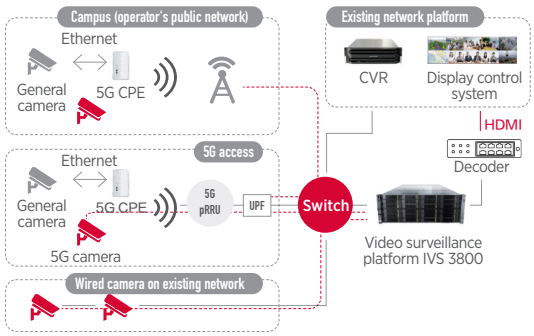


02 5G and Cloud based PLC

At present, PLC is troubled by high wiring cost, operation and maintenance chanllenges, and industrial control and coordination challenges. Take palletizers as an example. As there are only 2 palletizers on one floor, the entire production has to be stopped in case of any problem. There are 5 large equipment cabinets and 4 industrial PCs, resulting in complicated wiring, high cost and poor heat dissipation, so the door has to remain open. The complicated interaction among multiple levels of architecture (PLC, SCADA and MES) makes it challenging to program and debug, which easily causes problems.

Now these troubles have been solved through cloud-based PLC, which enables "wireless automated production lines". Such production lines boast several advantages. Wireless production lines: simple wiring, low cost and small footprint; quick adjustment of production lines: the layout of production lines may be adjusted quickly according to business needs; simple business collaboration: unified PLC programming on the cloud, highly efficient, and digitalized.

03 5G + campus security monitoring



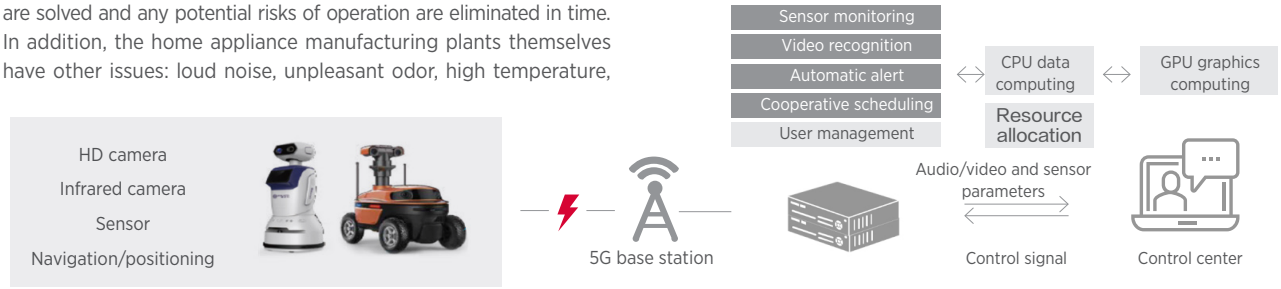
The existing campus monitoring system has a high fixed transmission cost. It uses video optical transceivers, bare fibers or xPON, and optical modems. The 12-core optical cable costs RMB 80,000 to 100,000 per kilometer on average, including about RMB 30,000 for trenching. Besides, This does not allow flexible node extension. Equipment powered by PoE has low online rate and the maintenance cost is high. The upload bandwidth on the existing 4G network is limited, which makes it challenging to support multi-channel high-definition video applications.

The monitoring capability has been improved through 5G + cloud, which features the advantages as follows. Wireless connection allows the deployment of video monitoring nodes on demand, including mobile monitoring mode. 5G technology improves uplink bandwidth to support applications such as high-definition videos and finer visual recognition. Cloud service capabilities such as cloud storage and GPU enable massive data storage and AI analysis for videos.

04 5G production inspection robots

In the MCA manufacturing campus that covers an area of 500,000 square meters, it takes 30 minutes to finish a patrol. At night or during holidays, security guard must rush to the scene to confirm if the alarm is true in the shortest time after an alarm goes off. A heavy workload is required for manual inspection. As there is a lot of production and logistics equipment in the manufacturing plants, it is necessary to arrange regular on-site inspection and maintenance by inspectors to ensure that any problems with the production line and logistics line are solved and any potential risks of operation are eliminated in time. In addition, the home appliance manufacturing plants themselves have other issues: loud noise, unpleasant odor, high temperature, small space, many types of complex equipment, poor vision, and large working area.

Inspection robots integrated with 5G technology are used to replace inspectors to inspect the operation of the production lines, which not only saves manpower but also guarantees round-the-clock inspections to enhance the efficiency of troubleshooting and avoid serious production accidents.



05 5G + machine vision AI

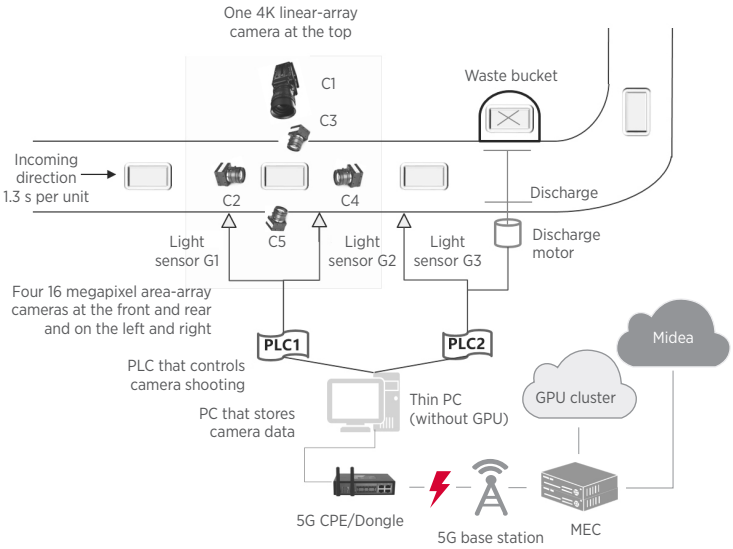
As part of the product process, visual quality inspection by machine is required for screws in the bottoms of microwave ovens and stamping parts in the panels. At present, cameras are placed on the front, rear, left, right and top of a microwave oven for visual inspection. This leads to pain points such as unstable quality for periodic manual spot checks (30 minutes once), high rework rate (300-500 pcs/20,000 pcs per day), high rejection rate (during spot checks, stamping problems can easily cause products to be rejected in batches), and expensive industrial computers (a local AI computer costs RMB 15,000 more/point).

The 5G network can meet the following requirements for machine visual inspection of production lines:

Bandwidth: Based on factors such as beat rate, photo size, data transmission, cloud processing time, it is calculated that 320 Mb of inspection images from the 5 industrial cameras are to be transmitted. (12 MB + 7 MB * 4 = 40 MB = 320 Mb. Assuming the transmission is to be completed in 0.5 second, the uplink bandwidth should be 640 Mbps, and 150 Mbps after the videos are processed by the video overlay algorithm).

MEC processing capacity: If the AI image inference time is 0.1 s, the GPU computing power on MEC must be matched accordingly; it requires high reliability.

Topology diagram of 5G + AI + cloud machine vision solution:



06 5G-based and AR-assisted regular inspection

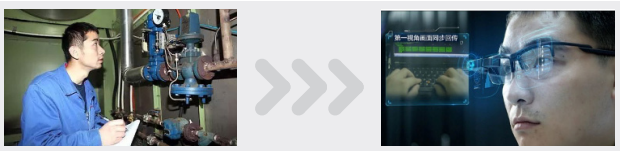
Regular inspections are required for the production equipment of the MCA to make sure that potential dangers and defects can be detected, prevented, and dealt with as early as possible.

1. Regular inspection must be done in every workshop, twice a day. The regular inspection involves many items (for example, in the sheet metal workshop, there are more than 80 pieces of equipment, and over 10 inspection items for each equipment, with more than 800 inspection items in total), and requires dedicated attention, which can easily lead to mistakes and omissions.

2. The workshops where the regular inspection is conducted are harsh with high safety risks, and the spot inspectors may feel fatigued and as a result, tend to be negligent or careless.

3. The regular inspection process and results are based on traditional work orders without process records, making it difficult to trace them.

The work flow of 5G-based AR-assisted regular inspection has been digitalized. A barcode is attached to each inspection location, and by scanning the barcode, the AR glasses will display all the inspection items at the location, along with the description and images of normal state of each item as well as voice prompts. During the regular inspection, the AR glasses help free the hands of the inspector and upload the recorded first-person videos and pictures in real time. In this way, the whole work flow of regular inspection is standardized and digitalized.



Shot in the first-person perspective with the smart glasses. With near-eye display, smart code scanning, voice recognition, gesture recognition, voice interaction, object recognition and other functions, the hands of on-site workers can be freed for more complex operations. The workers can have a more intuitive and faster access to process guidance, location tags, equipment information, alerts, and record equipment status, regular inspection results, emergencies, etc. more conveniently and accurately.

The real-time feedback of relevant information and real-time upload for regular inspection videos are ensured by the low latency and high bandwidth features of 5G.

07 5G-based and AR-assisted machine maintenance

Magnetron is a core component of microwave ovens, and its manufacturing relies heavily on automated equipment. However, automated equipment is troubled by high failure rate (40 failures a day in total). At night or during weekends, only a limited number of engineers are on duty, who are also tasked with other work. In case of a failure, the production may be halted as the production line workers do not have quick and effective guidance on troubleshooting, which will reduce the production efficiency.

The on-site problems/failures are handled at high cost, yet not in time. As the number of experts available is limited, on-site support needs cannot be met quickly in time. Besides, as the on-site workers are unable to learn the real-time status of the equipment being inspected accurately, experts have to take a long trip to the site at a high cost.

In the application scenario of 5G-based AR-assisted remote maintenance guidance, production line workers wear AR glasses to transmit the on-site information and first-person images of the equipment in real time to off-site engineers who can guide the workers to solve the problems quickly through real-time labeling. Relevant data is recorded and uploaded in real time, allowing an engineer to provide support for multiple workers at the same time.

REFLECTION

5G + cloud: Reducing the costs of local terminals such as local PLCs and AI/local servers, and their maintenance costs.

Wireless network: Reducing the costs of wired network construction and expansion (duct laying and cable installation) and their maintenance costs, and the costs of upper layer switch ports.

Flexibility: Reducing the costs of production line adjustment, as well as the loss caused by halted production.

Other networks incorporated with 5G: Saving the costs of deploying other wireless networks such as Wi-Fi and UWB.

Improved efficiency: Reducing the labor costs, and improving the efficiency of operation, maintenance and scheduling, as well as the material turnover and asset turnover.

Xiangtan Iron & Steel's 5G Smart Plant

5G networks allow us to create an information highway to connect the components in the Xiangtan plant. 5G networks enable equipment to operate with intelligence, producing mutually beneficial results.

Yu Weigang
Executive Deputy General Manager of Xiangtan Iron & Steel Co., Ltd.

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OVERVIEW

Xiangtan Iron & Steel was founded in 1958. It produces over 400 varieties of wide and thick plates, wires, and bars and has an annual steel production capacity of 14 million tons. The company has become the largest state-owned enterprise in Hunan and the largest wide and thick plate manufacturing base in the world.

Xiangtan Iron & Steel uses equipment and production processes with advanced technology throughout the steel production process, but it has encountered bottlenecks in efficiency improvement and energy consumption reduction. At the same time, the high-temperature and high-risk environment of the steel plant also makes it difficult to attract young workers. To further improve production capacity, reduce energy consumption, improve the work environment, and increase employee job satisfaction, Xiangtan Iron & Steel has decided to adopt ICT technologies, such as 5G, AI, big data, and cloud computing, in order to achieve a digital upgrade throughout all its processes and businesses and build a smart Industrial Internet platform for the steel industry. This will promote the high-quality development of the company while promoting the industry's evolution toward smart steel and green steel.

In September 2019, representatives of Xiangtan Iron & Steel, China Mobile Hunan, and Huawei met at Xiangtan Iron & Steel to sign a cooperative agreement to"Embrace the 5G Era and Jointly Construct a Smart Factory". China Mobile Hunan implemented "Three Basic Projects" and built "Three Smart Platforms" for Xiangtan Iron & Steel, establishing a benchmark case for cross-sector smart factories.

In June 2020, Xiangtan Iron & Steel, China Mobile Hunan, and Huawei continued to explore 5G applications in Phase 2 of the 5-meter plate plant project. This provided ample evidence that the customer recognized the potential of 5G in the steel industry and was confident that it would continue to improve efficiency and create value for the industry in the future.

CHALLENGES

The main production lines of Xiangtan Iron & Steel have basically achieved automation, but the further promotion of smart steel plant construction is hampered by the large area of the production plant, harsh production environment, and strict electromagnetic shielding. The interference with traditional wireless signals results in severe packet loss, making it impossible to achieve the necessary network bandwidth and real-time performance. As a result, many tasks must still be performed manually. This makes it imperative that we promote the construction of 5G intelligent manufacturing in smart steel plants. Based on the features of the steel production process, the key points to consider for 5G + industry intelligent transformation are:

Automation of frontline operations: The steel production process involves many employees, but the environment is harsh, demanding, and has heat-related risks. By replacing the employees in this process with robots or achieving unmanned operations, workplace safety and employee satisfaction can be improved.

Connection problems: Key metallurgical equipment is critical to the safety and stability of production. The common regular inspection and maintenance system reduces production efficiency and increases the workload of inspection and maintenance personnel. Under the limitations of traditional installation conditions and bandwidth restrictions, some equipment subject to vibration and rotational movement is not equipped with sensors or the sensors do not provide much information. If all key equipment was equipped with sensors and the real-time work status and parameters of the equipment was centrally monitored from a platform, inspectors could monitor the production process from their cell phones or other devices and immediately see the work statuses of equipment.

Network connectivity is a prerequisite of digital and intelligent plants: By transitioning from wired to wireless connections and from multiple

connection methods to a unified 5G + fiber optic connection mode, we can work together to build a low-latency and highly reliable underlying network. Connectivity is necessary for the in-depth interconnection of all elements and stages.

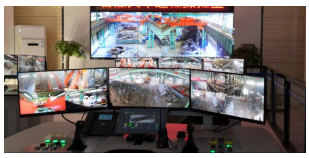
SOLUTION AND VALUE

In 2019, the project first completed full 5G coverage for the open areas outside the 5-meter plate plant, the converter control building, the steel scrap bay, and the slag bay. Several pilot application scenarios were explored, taking advantage of improved HD video transmission and control signal data transmission between programmable logic controllers (PLCs). These pilot projects include remote/unmanned crane operation and HD video surveillance for high-risk areas. In 2020, building on Phase 1 of the project, multivariate data collection, AI machine vision quality inspection, and several other applications were added.

01 5G + Smart Cranes

Cranes are used for loading, unloading, handling, and transportation, making them one of the most important pieces of steel production equipment and a key factor for the operational efficiency of steel plants. Cranes often operate high above the factory floor. In the past, manual operation was required from the crane operating room. This was inefficient and exposed employees to a harsh and hazardous work environment. To increase efficiency and eliminate operational risks, it is necessary to develop unmanned crane systems.

To achieve the remote operation of unmanned cranes, the cranes are equipped with a 3D scanner, rangefinder, codec, and multiple HD cameras. With 3D laser contour scanning technology, the system can obtain a picture of surrounding materials, vehicles, vehicle heights, and loading and unloading position information. The 5G network provides ultra-large bandwidth, ultra-fast speed, and ultra-low latency



for the real-time transmission of data to servers. Then, the data can be processed to create 3D models, compute action command sets, and issue the commands to the crane. This allows cranes to perform unmanned and automated loading and transportation. The 5G remote crane operation solution solves the problems of poor industrial Wi-Fi coverage and capacity, poor interference prevention, difficulty in fiber optic wiring, high costs, and complicated maintenance. At the same time, it greatly improves the work environment and significantly increases labor productivity.

02 5G + HD Video Surveillance

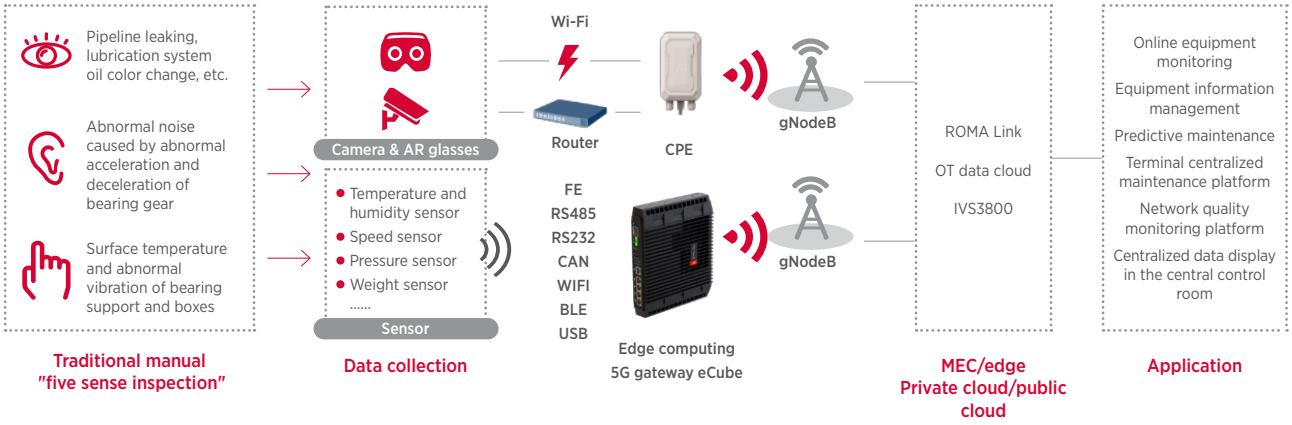
This solution aims to protect plant property, ensure personal safety, and facilitate management. The smart video surveillance system can provide video surveillance and recording storage for important areas, passageways, entrances, and exits in order to facilitate subsequent investigation and retain important evidence. In-plant video surveillance is an important component of the production scheduling system. It is deeply integrated with scheduling terminals, production data, and other subsystems to meet the needs of the manufacturer for routine production scheduling, security event monitoring, and emergency response.

Multi-scenario video surveillance

03 5G + Multivariate Industrial Data Collection

In order to ensure the long-term, stable, and reliable operation of the steel plant, key equipment in the plant must be equipped with various sensors to monitor vibration, temperature, humidity, gas/liquid flow, and other key information in real time. This will allow the plant to quickly detect and solve problems. Different sensors use different industrial protocols and have different network transmission methods and architectures. This makes it difficult to manage the collected data in a unified manner.

To address this, the 5G data acquisition solution can achieve the collection and protocol conversion of heterogeneous sensor data in industrial scenarios through a unified edge computing gateway and a wide range of industrial interfaces. This provides a comprehensive solution for enterprises to connect different IoT devices. This solution uses 5G low-latency wireless transmission (< 50 ms) to avoid wiring in the complex factory environment and significantly improves the efficiency of deployment, inspection, repair, and maintenance. By incorporating edge AI and containerization technology, the solution can adapt to the diverse needs of enterprises in the future and facilitate unified management and maintenance, application capability enhancement, intelligent analysis, and continuous innovation. In addition, it ensures the service quality and link quality are transparent and manageable throughout the entire process.



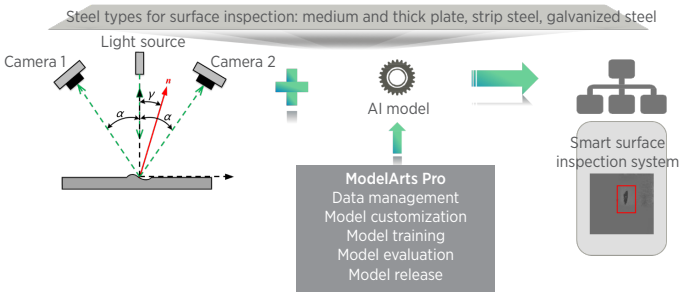
04 5G + AI Machine Vision

Steel Surface Quality Inspection

With the development of technology and increasing quality requirements, steel surface quality inspection has become essential. For example, automobile panels cannot have more than two surface defects, and household appliance steel plates must be completely free of defects.

Currently, quality inspection of industrial products is based on the traditional manual inspection methods. A slightly more advanced inspection method is to compare the product to be inspected with a predetermined defect type library. The detection accuracy and efficiency of the above methods cannot meet the current quality requirements, and the methods lack learning abilities and detection flexibility, resulting in low detection accuracy and efficiency. In addition, due to low computing power, and high latency and low bandwidth of the 4G network, data cannot be systematically linked and is processed offline, resulting in high labor costs.

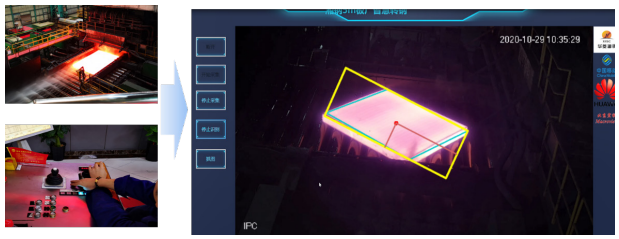
Leveraging the high bandwidth and low latency of 5G, micron-level targets can be observed through 5G + AI + machine vision. The information obtained in this manner is comprehensive and traceable, greatly improving the efficiency and accuracy of product quality inspection.



Automatic Rolling Detection

In the steelmaking process used in steel mills, one of the main procedures is the forming rolling process, in which the slab is passed through one to four rolls to roll it to the required thickness. Currently, this process usually requires manual operation, requiring workers to be on duty 24 hours a day. If a worker makes a mistake or works slowly, production efficiency will suffer. The application of AI-empowered automatic rolling detection can automatically detect the direction of steel rolling through 5G + AI cameras. This automatic control system can control the rotation of the slab based on visual input, thereby reducing manpower and improving steel rolling efficiency.

The AI-empowered automatic rolling detection system is mainly composed of 5G cameras, PLCs, wireless access points, an automatic control system, an algorithm preprocessing server, a centralized monitoring center, and a cloud AI training platform. This means algorithms and models can be learned on the cloud, and strategies can be distributed to the servers in the industrial campus. AI visual judgment is performed based on the images collected by the cameras, providing the corresponding command basis that allows the control system to make accurate judgments on steel rolling actions, angles, and other parameters.



REFLECTION

The Xiangtan Iron & Steel 5G Smart Plant project is a key project in the company's effort to build a "two-type" demonstration enterprise for the Intelligence 4.0 era with a smart and energy-saving ecosystem. It also makes Xiangtan Iron & Steel the first Chinese steel enterprise to tap into the commercial value of 5G Industrial Internet applications.

After the initial commercial launch of the Xiangtan Iron & Steel project in September 2019, Phase 2 of the project, which began in June 2020, continued to expand the application of 5G. This demonstrated that the customer understands the potential of 5G applications to reduce costs and increase efficiency in the steel industry and is confident that 5G will continue to improve efficiency and create value in the future.

High-Quality Private Industrial Network and Application Innovations of Baosteel Zhanjiang Based on Independent 5G Core Network

Discrete points, mobile equipment, and moving people are the bottlenecks hindering data awareness during the advancement of smart steel factory. 5G-based wireless networks provide a convenient channel for the interconnection across the these objects. Baosteel Zhanjiang Iron and Steel Co., Ltd. is committed to building a 5G-based private industrial network to connect people and equipment securely, which can empower the five core elements of enterprises - quality, equipment, logistics, energy conservation and environmental protection, and safety - and further enhance the enterprise's smart manufacturing levels.

Guo Xiaolong
Deputy General Manager of Baosteel Zhanjiang Iron and Steel Co., Ltd.

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OVERVIEW

Baosteel Zhanjiang Iron and Steel Co., Ltd. (hereinafter referred to as Baosteel Zhanjiang) is one of the four bases of Baoshan Iron & Steel Co., Ltd. Located in Donghai Island, Zhanjiang, Guangdong, the company's factory area covers 12.58 km^2. Baosteel Zhanjiang has always comprehensively implemented Xi Jinping's thought on socialism with Chinese characteristics in the new era and the spirit of the 19th CPC National Congress. It responds to the nation's call for supply-side structural reform, implements an innovation-driven strategy, and promotes smart manufacturing and clean production, as part of its efforts to become a demonstration base for high-quality development of the steel industry.

China's steel industry is working towards its transformation goals of cutting overcapacity, improving quality, and improving structure. Transforming China from a steel manufacturer of quantity to one of quality through smart manufacturing is the common trend for development. In line with the overall planning and production management requirements of Baosteel Zhanjiang for smart manufacturing, China Unicom Guangdong partnered with the 5G industry ecosystem to tailor-make the world's first private industrial network based on an independent 5GC core network. The private independent core network is connected to underlying implementations to physically isolate production data and personal data in the campus, which can also help verify and incubate 5G industrial terminals based on a high-quality private network to continuously boost innovation in 5G industrial production application. This case has pioneered a self-service and self-operation platform in an enterprise-level private network in China, further unleashing the private network's self-service, self-configuration, self-management and self-planning capabilities while ensuring users' comprehensive management of the private network. Through a 5G network, the solution helps Baosteel Zhanjiang grow into a world-class smart steel factory.

CHALLENGES

Steel production is a dynamic and complex production system that integrates resource, space, time, and temperature constraints. This complex production process is accompanied by highly hazardous scenarios such as high temperature, high pressure, a dusty environment, and inflammables and explosives, which poses challenges to the planning and construction of the production network.

1. High network security and stability requirements: The steel industry has high standards and requirements and strict security metrics to follow. The industry has stringent requirements on the reliability and stability of the 5G network, making it difficult to promote the technology in the steel industry in an all-round and prompt manner.

2. Slow development of industrial-grade 5G terminals: In the steel industry, most operational areas feature a high risk, high temperature, dusty environment, and explosiveness. For this reason, it is out of traditional 5G terminals' capacity to maintain stable and continuous

operations. Stable and reliable 5G industrial terminals are needed.

3. Long application incubation periods: In view of the continuity and particularity of steel production processes, incubation practices of 5G applications in real production scenarios usually take a long time. Each application requires a long verification period before it is tested and launched. The prolonged incubation period is not conducive to the rapid promotion of 5G applications in the industry.

SOLUTION AND VALUE

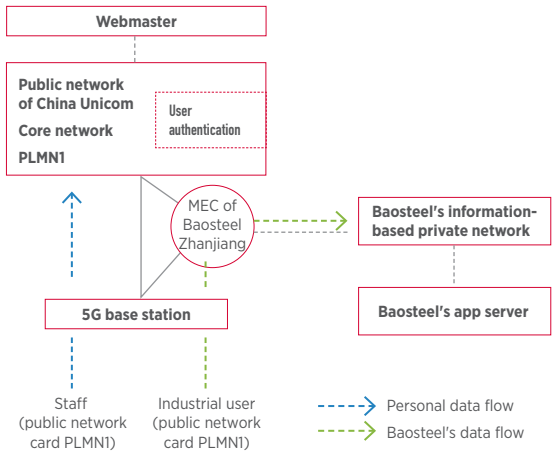
To address the needs of the smart manufacturing scenarios and factory staff of Baosteel Zhanjiang, China Unicom Guangdong has formulated a 5G-based private industrial network solution for Baosteel Zhanjiang. The following two solutions are available.

01 Integrate MEC in underlying facilities to share the operator's public core network.

The main network architecture in this solution is that the core network is shared with the operator's network and MEC is integrated at the industrial park's level.

Staff and industrial users use the public network card (PLMN1) configured by China Unicom, and user authentication is performed on the operator's public core network, supporting data, voice, and SMS services over the public network.

The data services for industrial users are distributed to the enterprise's internal servers directly through MEC in the park to ensure that data is not shared with external parties.

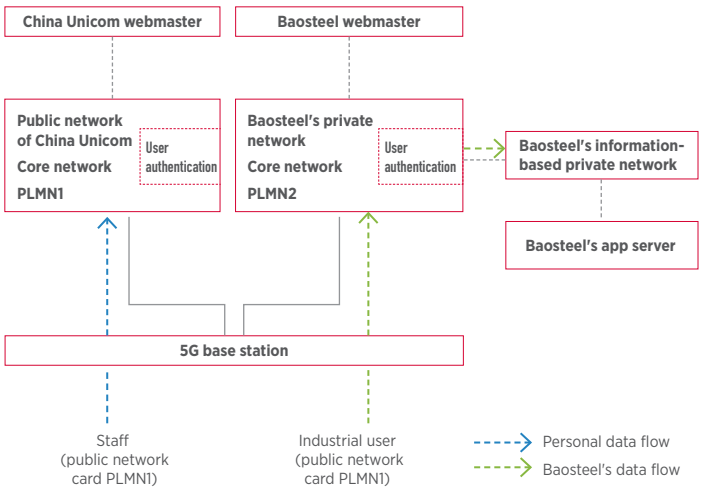


02 Establish a 5G core network in the park that is independent from the public network

The main network architecture in this solution is to establish a private core network in the park that is independent from the operator's public network. To access the communication network for business operations, the user terminal must first complete user authentication. During user authentication, the terminal reads parameters (such as PLMN, IMSI, and secret key) in the SIM card and performs mutual authentication with the corresponding core network. Therefore, the corresponding user cards are required to access the two isolated core networks and use the services.

Staff use the public network cards (PLMN1) configured by China Unicom, and user authentication is performed on the operator's public core network, supporting data, voice and SMS services over the public network.

Industrial users use the private network cards (PLMN2) configured by Baosteel, and user authentication is performed on Baosteel's private core network, supporting data services. The data flows go directly to the enterprise's internal servers through Baosteel's private network, without going out of the park.



With a 5G-based private industrial network established, Baosteel Zhanjiang has enabled physical isolation from the public network to ensure production data security. Meanwhile, it has pioneered a self-service and self-operation platform in an enterprise-level private network in China, further unleashing the private network's self-service, self-configuration, self-management and self-planning capabilities while ensuring users' comprehensive management of the private network.

Private network platform

Based on a well-fledged network and the industrial-grade 5G terminals jointly developed with partners, China Unicom Guangdong and Baosteel Zhanjiang have been jointly exploring 5G application in the steel industry, and planned about 51 application scenarios. Specifically, five industrial applications including online monitoring of large blowers, tier-1 high-risk maintenance monitoring, and 5G + AR intelligent inspection have been launched and applied at scale.

5G-based online monitoring of large blowers

Large blowers are essential in steel factories, and their safe and stable operations play an important role in the steelmaking process. Blowers generate massive amounts of data during operations. The traditional 4G technology could not support real-time data transmission and online monitoring. As a result, daily manual inspections were necessary, leading to low troubleshooting efficiency due to uncontrollable inspection quality when failures occurred. Currently, all blowers across the factory have been connected via 5G to achieve online monitoring and diagnosis.

Values of 5G: Improve the failure early warning rate by 90%, and increase the operation and maintenance efficiency by 50%.

5G-based real-time monitoring of tier-1 high-risk operation

Large steel factory areas witness a large number of outdoor operations as well as inspections and maintenance, most of which are on a mobile basis and in an operating environment that features high temperature, high risks, high altitudes, etc. The operational safety of personnel is critical to safe production. The traditional 4G network has insufficient bandwidth to support real-time monitoring with high-definition cameras, and postmortem retrospective analysis is the only option. The project has enabled platform-based real-time monitoring throughout the processes over 152 tier-1 high-risk operation points across the factory by utilizing the 5G technology, and will further integrate AI-empowered behavior detection. When operation personnel's action is unsafe, the solution can issue an early warning to the backend and the personnel themselves, which helps prevent accidents.

Values of 5G: Increase the early warning rate of safety incidents by 30%.

5G + AR intelligent inspection

The park has a huge daily operation and maintenance workload, with high requirements on the professional level of on-site maintenance and repair personnel. Utilizing the low latency feature of the 5G network, the park has integrated AR glasses that have high-definition cameras and support voice calls to enable online, real-time interactive inspections by on-site troubleshooting personnel and technical experts in the backend.

Values of 5G: Greatly lower down the technical level requirements on on-site maintenance personnel, optimize productivity, achieve intelligent equipment inspections, and increase troubleshooting success rate by 65%.

5G-based intelligent robot inspection of belt

Belt conveyors in the factory are far away from each other and the site environment is harsh, compromising the efficiency of traditional manual inspections. As a result, troubleshooting cannot be performed in time. The inspection robots integrated with industrial-grade high-definition cameras can transmit inspection images and videos to the backend system in real time via the 5G network to locate faults precisely.

Values of 5G: Improve inspection efficiency and elevate troubleshooting efficiency by 60%.

5G-based real-time monitoring of environmental dust in the factory

The iron burning area of the steel mill exhausts a large amount of dust due to production needs, which has a certain impact on the environment of the factory. In response to this problem, Baosteel Zhanjiang has equipped the area with a dust detector to monitor the environment in real time by utilizing the 5G network.

Values of 5G: Effectively control the dust content in the factory environment in real time to help meet the strict requirements of environment-friendly production.

INNOVATIONS

The first in the world to establish a private industrial network with the 5GC core network to ensure customer data security through physical isolation.

Support self-service, self-configuration, self-management and self-planning of the private industrial network by building a self-service platform for enterprise-level private networks.

Ensure reliable data transmission of data services relying on the SA end-to-end slicing capability to establish a secure and high-quality 5G network. With MEC supported on the underlying network, the open computing power and platform promote the integration and innovation of more than 32 5G steel industry applications.

REFLECTION

The intelligent transformation of the steel industry contributes to the success of this project. By utilizing the 5G technology to empower intelligent steel manufacturing, the project marks Baosteel Zhanjiang's leading exploration in the 5G-based steel industry applications. With the help of 5G private industrial network and incubated 5G applications for the steel industry, the project has improved the quality and structure of the factory, further promoting the intelligent transformation of the company.

As an innovation demonstration base of China Baowu Steel Group Corporation Limited (China Baowu), Baosteel Zhanjiang has successfully implemented 5G applications, providing valuable experience for intelligent steel manufacturing. The experience can be quickly replicated within China Baowu. Meanwhile, the democratization and application of 5G and Industrial Internet technologies have greatly promoted the maturity of the 5G industry chain. The iron and steel industry is a national strategic fundamental industry, being inherently demanding in terms of both technology and safety. The successful 5G application in the steel industry is of great significance to 5G application promotion in the entire manufacturing sector. The intelligent development of the steel industry can greatly fuel the high-quality and innovative development of China's manufacturing industry.

In the future, Baosteel Zhanjiang will continue its in-depth cooperation with China Unicom Guangdong to focus on the following areas.

1. To further ensure the security of the 5G-based private industrial network, China Unicom Guangdong will deploy a second set of 5G-empowered equipment with an independent core network to enable carrier-grade disaster recovery for the 5G private network and ensure stable operations of the 5G private industrial network of Baosteel Zhanjiang even in unexpected situations, without affecting the normal operations of online services.

2. Categorize network requirements based on the 5G applications in the steel industry, and enable SA end-to-end slicing by utilizing network slicing. This can ensure reliable transmission of similar data services and effectively maximize network supports.

3. Currently, 5G applications are deployed in Baosteel Zhanjiang's data center. Next, an edge cloud management platform will be configured by connecting the factory area to the 5G-based MEC platform to promote 5G application innovation with open computing power. The project will also provide more standardized application algorithms by integrating the industrial ecosystem to expedite incubation and innovation of 5G applications.

4. Relying on the well-fledged 5G industry chain, Baosteel Zhanjiang and China Unicom Guangdong will continue to explore 5G applications in the iron and steel industry. They expect to implement precise personnel positioning, drone inspections, and other 5G applications in the factory area to help Baosteel Zhanjiang grow into a world-class 5G-empowered smart steel factory.

Conch Group 5G Smart Manufacturing

One major difference between 5G and previous generations of communication technologies is the possibility to combine 5G network capabilities with AI, cloud, machine vision, and VR technologies. This allows 5G to meet the different levels of performance, reliability, and security required by the digital transformations in various industries. China Telecom worked with various ecosystem partners to establish the Conch Group 5G Smart Manufacturing project. This project applies scenario-specific solutions combining 5G and industrial Internet to the process running from cement raw material mining, through product production, to shipment, which provided ample evidence of the important role played by 5G technology in the process manufacturing field. In the future, we will work with our partners to jointly promote industrial development, incorporate 5G into industry and daily life, and build a more intelligent future.

Zheng Jiasheng
Deputy General Manager of China Telecom Anhui

SOLUTION PARTNERS

CONCH 海螺集团 | 中国电信 CHINA TELECOM | HUAWEI | 青牛云智 TsingNew | Sunwin 赛为智能

OVERVIEW

Cement is an important building material that is essential to the construction of the national economy. China is a major cement producer and consumer, accounting for 60% of the world's total cement output. In recent years, the cement output has stabilized at around 2.3 to 2.4 billion tons per year. In 2019, the main operating revenue from cement businesses in China amounted to RMB 1.01 trillion, a year-on-year increase of 12.5%. As an important basic industry of the national economy, the cement industry has become an important indicator of national economic and social development and overall strength.

Conch Group is one of the largest building material enterprise groups in China, ranking 38th out of the top 500 Chinese manufacturing companies, with an annual cement output of 353 million tons. Conch Group has actively embraced the trend of applying 5G technology to transform traditional industries. It is working with China Telecom Anhui and Huawei to conduct 5G network and application practices in Conch cement mines, factories, and ports and to actively explore potential applications in business security, remote business, and business AI.

38th
Top 500 in China's Manufacturing Industry

353 million tons
Annual Cement Output

CHALLENGES

There are many production and operational challenges in the manufacturing industry. For example, standalone intelligent equipment has not yet been widely adopted, systematic intelligent equipment clusters have not yet been formed, and most cement manufacturers are still in the "automation + manual labor" stage. The main problems are that the distributed control system (DCS) collects few information signals, mining and management operations are not fine-grained, IoT facilities are not up to date, key parameters are set manually, variance in manual operations affects production, the quality inspection cycle is long with a significant lag, and many human factors must be considered. The 5G construction and application exploration practices of Conch Group's cement smart factory demonstrate that these key challenges require 5G-driven solutions. Conch Group has a strong partnership with China Telecom and Huawei. In August 2019, the partners launched 5G network construction in the Wuhu and Quanjiao cement plants. This represented a significant upgrade in basic connection capabilities, based on which we could better leverage cloud, computing, and AI to enable intelligence for all scenarios. Then, we successfully and quickly promoted many applications involving business security, remote business, and business AI, such as unmanned mine trucks, drone blast area patrol, HD video surveillance of key areas, employee safety behavior detection, remote control of water pumps, and remote control of ship loading.

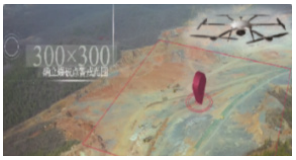
SOLUTION AND VALUE

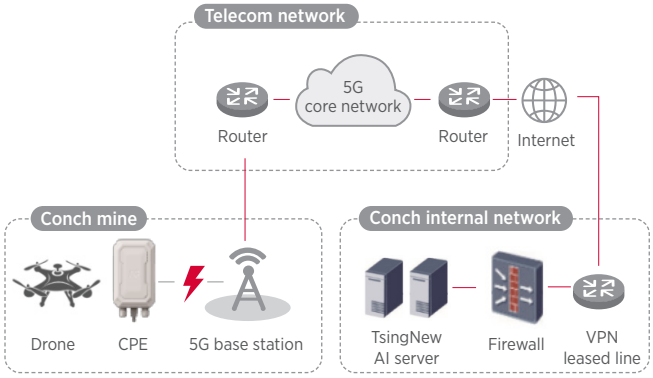
01 AI-based Drone Blast Area Patrol + Terrain Sampling

Before the blasting of a cement mine, the area must be cordoned off to prevent entry. The traditional manual patrol methods are inefficient and cannot completely prevent people from entering the area.

Conch pioneered drone blast area patrol and geomorphologic update and analysis applications in the mining areas. This solution was first applied in surface mine blasting. However, it not only can be applied to non-metal above-ground mines such as cement mines, but can also be used in other above-ground blasting scenarios. The drones use 5G to transmit HD surveillance video of the mine site to China Telecom's e-Cloud AI platform for analysis. When it detects people or equipment within the blasting area, the AI system issues an alarm through the integrated AI platform. After blasting, the drones can collect GIS terrain changes and update 3D models to guide subsequent blasting and extraction operations.

In this application, the 5G super uplink technology ensures 5G coverage and bandwidth across varied terrain. The original AI recognition range has been expanded from 500 meters to 2 kilometers. Due to large-scale monitoring without blind spots, fewer guards are required to patrol the area. This avoids personnel safety accidents, improves the efficiency of terrain data collection after blasting, and represents a key step forward in the integrated management of unmanned mines.

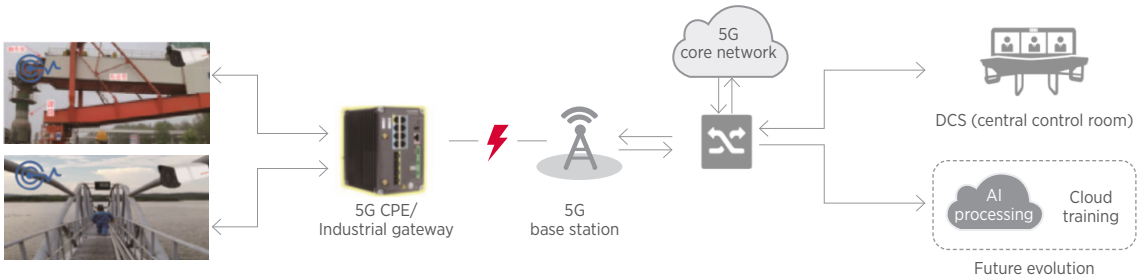




02 5G Industrial Internet + Remote Control and Data Collection of Water Pumps/ Ship Loading Devices

By collecting data from water pumps 10 kilometers away and connecting PLC control information, on-site video, pump revolutions, and water output data to the DCS control system of the control center, we can shut down water pumps remotely, so the two employees required for long-term water pump maintenance on site are no longer needed.

Based on the characteristics of cargo transportation on the Yangtze River, the ship loading devices in the river port system have been upgraded with 5G remote control. Each loading device is equipped with four camera points. After the video is returned, AI algorithms assist in identifying key information such as ship statuses, slip locations, and cargo positions. This can facilitate remote operation of loading devices manually to greatly improve the efficiency of the process.

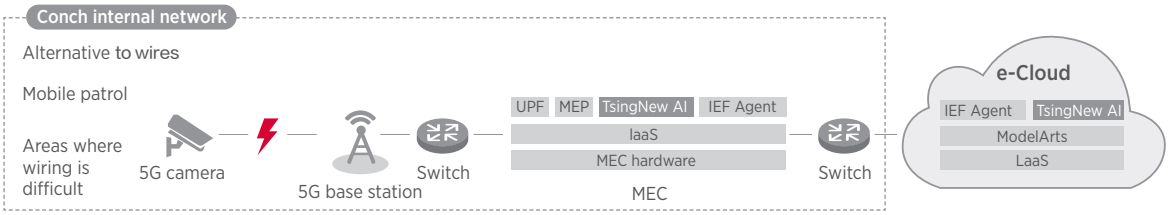


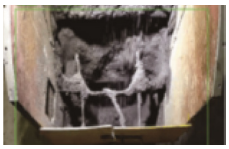
03 5G + AI + Cloud + HD Video for Smart Manufacturing in Multiple Business Scenarios

Leveraging the high bandwidth and reliability of 5G, we determined the points that require human monitoring in the production process to ensure the safety of cement manufacturing and industrial campuses. We developed special algorithms based on AI and developed machine vision applications to solve cargo port blockages, conveyor belt snag detection, ash pollution detection, and tip valve detection. At the same time, we

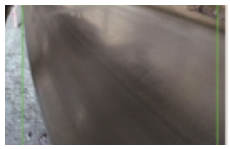
provided AI security detection of unsafe behaviors by personnel in the industrial campus. When the alarm threshold is reached or unsafe behaviors are recognized by AI, it will trigger real-time alarms.

Improving production efficiency through 5G + AI can remove the need for more than five manual inspections on the production line, which increases the efficiency of inspection and monitoring by a factor of 3 to 4, while avoiding 95% of losses caused by man-made and mechanical accidents.





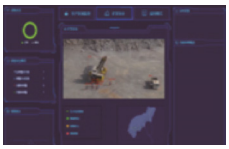
Cargo port blockage



Conveyor belt crack/ snag monitoring

Ash detection

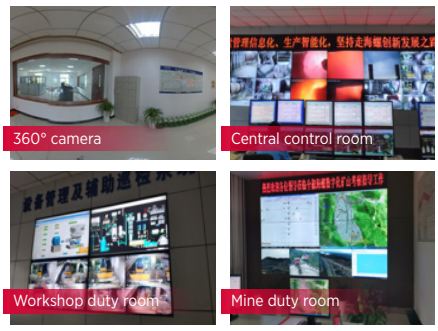
Tip valve status detection

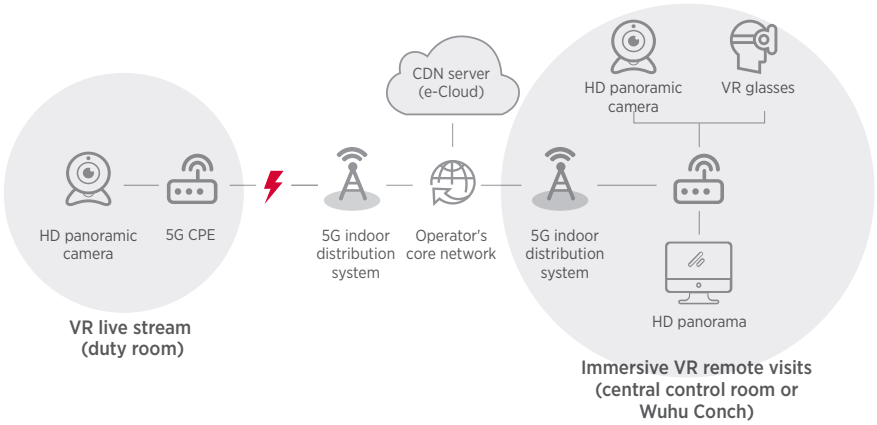


AI smart forecasting and monitoring platform

04 Remote VR Visits

The Conch mining sites often host visits by small and medium groups. The 5G network's high bandwidth makes VR remote visits possible, which does not interfere with normal production and avoid unnecessary safety risks. A 360-degree camera is placed in the central control room, workshop duty room, and mine duty room, and VR glasses are provided in the central control room. The 360-degree cameras are used to collect images from the two duty rooms and the voice explanations of the on-site personnel. The visitors can use VR glasses to watch remotely from the central control room.





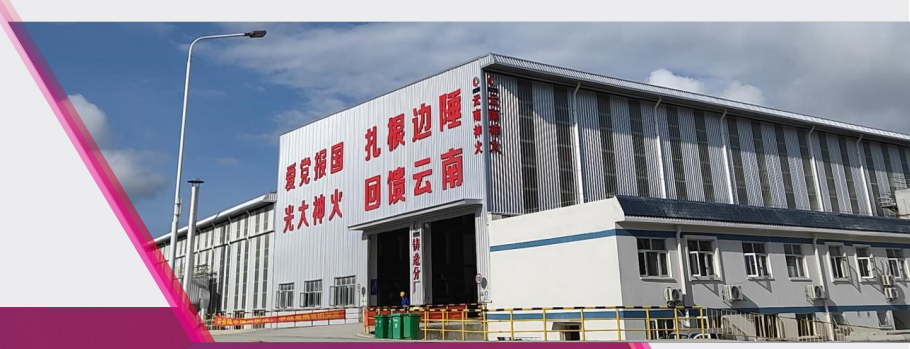
REFLECTION

Among the 5G deployment practices of Conch Group, the application of super uplink technology is of particular note. This technology increases the uplink rate in the areas close to the base station by 20%–60% and that of the areas of weak coverage along the edge of the coverage zone by up to 300%. With this feature and by using AI to ensure real-time video clarity and accurate identification, the blast alert coverage can be expanded from 500 meters to 2 kilometers. This technology is currently the subject of a joint patent application and we are promoting it as a global 5G technology standard.

The application of 5G + industrial Internet in the cement industry is still in the early exploratory stage, but an initial set of typical application cases has been developed. As 5G technology matures, industrial applications are further explored, and the commercial value of these applications is recognized, 5G + industrial Internet will surely become the main driving force and an important path for digital transformations in the cement industry.

The future plan for this project is to go deeper into the cement production process and use the industrial Internet platform to converge the industrial big data links of more than 15,000 data mining points in the production process. This will facilitate data management and decision-making to enable a qualitative leap in the safety, environmental protection, efficiency, and intelligence of cement production.

Yunnan Shenhuo 5G Smart Plant



Yunnan Shenhuo has since its inception focused on building a smart plant for green hydroelectric aluminum, featuring first-class equipment, processes, management, and environment. With advanced technologies like 5G, edge computing, big data, and AI, Yunnan Shenhuo aims to create a leading plant while maintaining down-to-earth practice.

Wang Hongtao
Chairman of Yunnan Shenhuo Aluminum Industry Co., Ltd.

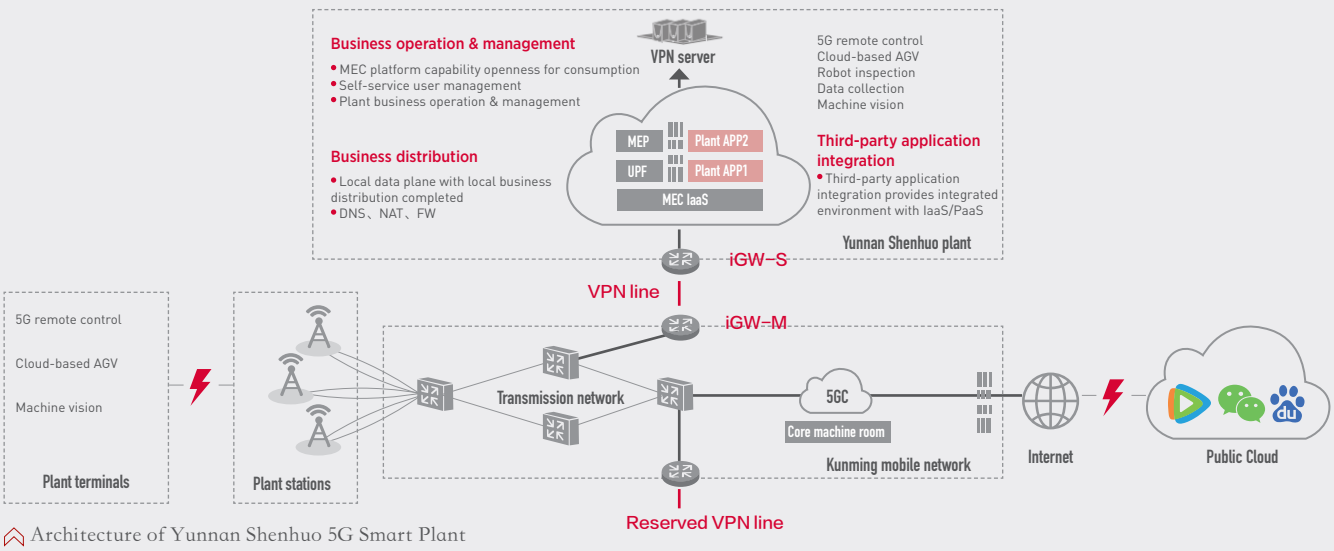
SOLUTION PARTNERS 神火集团 | 中国移动 China Mobile | ZTE中兴

OVERVIEW

In June 2020, Yunnan Shenhuo, together with China Mobile and ZTE, launched a smart demonstration plant project to gradually develop a technology-centric ecosystem and industrial chain, thus driving the development of relevant industries like logistics and aluminum processing. With 5G network and multi-access edge computing (MEC) at the core and supported by capabilities like industrial Internet platform, digital twin, big data, and AI, the smart plant aims to incubate innovative 5G applications.

Thanks to China Mobile, Yunnan Shenhuo has built seven 5G stations for network coverage and put commercial MEC in place. The construction plan for the next two years has also been developed, making 5G a binder in the smart plant to facilitate the change from cloud-network synergy to cloud-network integration. In this way, the smart plant can integrate network resources, computing resources, and corporate management system horizontally. Beyond the integration of IT, OT, and CT, the plant will also promote deep integration of innovative applications and the smelting control system to help the non-ferrous metal smelting industry tackle technical difficulties in the traditional model and move toward smart operation.

The project has incubated the following innovative 5G applications in the MEC environment: fiber optic strain and temperature monitoring system—electrolyte leakage analysis, intermediate frequency furnace precision analysis under high temperature (1400°C), crack detection on bridge crane conveyor, visual meter reading, remote centralized control of bridge cranes, high accuracy positioning, and environment monitoring. These data-driven applications can effectively solve problems in non-ferrous metal smelting, for example, unstable process control and complicated equipment failure. Automation equipment can contribute to a comfortable workplace by improving production efficiency, reducing manual workload, and minimizing the incidence of safety accidents.



Architecture of Yunnan Shenhuo 5G Smart Plant

CHALLENGES

The non-ferrous metal smelting industry is a typical process industry, involving a great variety of raw materials and products, long workflow of complicated processes, and harsh working conditions. On the whole, the non-ferrous metal industry, a late starter in intelligent manufacturing, is not positioned yet for high-quality development. There are many problems, e.g. a great variety of smelting equipment, various sources sensitive to safety and environmental requirements, and varying levels in automation management. In particular, small players are troubled by backward processes and equipment, dependency on manual operation, and prominent problems in environmental protection and workplace safety. Some processing companies still record production and operation data on paper and fail to build a flexible organization with effective online monitoring and quality control.

At present, non-ferrous metal producers have two pain points in smart plant construction: industrial networking and information construction. In a traditional industrial networking scenario, customers will encounter difficulties in the following three aspects:

(1) Poor signal with inconvenient cable deployment
(2) Low efficiency; unable to support flexible manufacturing
(3) High cost in installation and maintenance

Traditionally, the plant relied on isolated information silos that use vertical communication. As a result, data was not shared and business could not be integrated. The following pain points have been seen for a long time:

(1) Poor security: hidden safety hazards in terms of plant, equipment, and environment.
(2) High energy consumption: energy efficiency responsibilities are not clearly defined and effective energy-saving measures are not available.
(3) Low efficiency and high cost in operation: decentralized management involving many objects and heavy dependency on people for plant management.

Considering the problems of traditional wireless technology and information system, the plant needs innovative wireless communication technology to build an industrial Internet platform that can help it save energy, reduce consumption, and improve quality. At the same time, plant data can be unloaded from the local server and put in private cloud, helping the sector transform from "terminal-connectivity-cloud" to "cloud-edge collaboration".

SOLUTION AND VALUE

01 Monitoring Center

Yunnan Shenhuo Monitoring Center

With such software and hardware systems as video surveillance and electronic sand table, the monitoring center can perform tasks like security monitoring, environment (energy consumption) monitoring, and plant display. It can also support information release, emergency response, comprehensive management and control, and the display of plant operation at all levels. The center will continue to improve, accessing the existing 27 systems and realizing 3D real-time dynamic display of the plant.

02 5G-based fiber optic strain and temperature monitoring system —electrolyte leakage analysis

With 5G technology, the fiber optic strain and temperature sensing system can include sensors that work under high-temperature (-180-350°C), harsh conditions for a long time and in the ultra-dense network. The problems in traditional communication mode can also be solved, for example, the access of ultra-dense network, wiring difficulty, and data offloading within the border of the plant.

03 5G-based visual meter reading in air compressor room

Site Image and Diagram of 5G+ Visual Meter Reading in Yunnan

5G technology can enable automatic visual meter reading for air compressors. It can optimize staffing while creating a comfortable workplace. The digital centralized monitoring can also enable real-time alerts and make management more efficient, ensuring production safety in the plant with technological innovation.

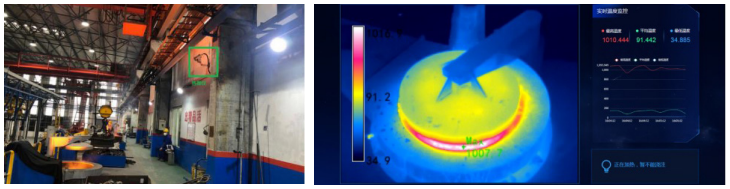
04 5G-based off-track conveyor crack monitoring

Site Image and Diagram of Conveyor Crack Monitoring

In addition to automatic cleaning of dust and aluminum skimming, closed conveying pipelines are equipped with video-capture devices (including industrial line scan camera/lens/light sources) to scan the conveyor surface for analysis. The captured images will be sent via 5G network to the machine vision platform for GPU analysis with professional algorithms. In case of cracks on the conveyor belt, a real-time alert will be triggered.

05 5G-based precision analysis of 1400°C molten iron in intermediate frequency furnace

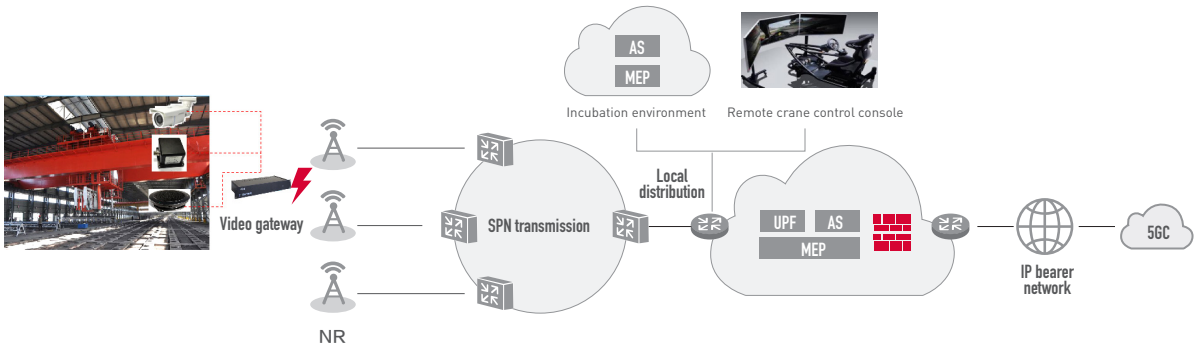
A professional dual-color high-temperature camera can be used for non-contact temperature measurement of the furnace. The images captured by the camera will be sent via 5G network to the machine vision platform in the machine room of Yunnan Shenhuo for GPU analysis with professional algorithms. The temperature of molten iron will be displayed in real time to ensure the optimum discharge temperature of 1400°C.



Site Image and Diagram of Intermediate Frequency Furnace Precision Analysis in Yunnan Shenhuo Casting Workshops

06 5G-based remote centralized control of bridge cranes

The bridge cranes at Yunnan Shenhuo are manually controlled, leading to problems like high labor costs, low efficiency, high risk, uncomfortable working environment, and competition for cranes. Yunnan Shenhuo has installed programmable logic controllers in five bridge cranes in the alumina warehouse. The control signal and information captured by HD video devices on cranes' bodies and walls can be sent back in real time with low-latency 5G technology, allowing operators to control the cranes in the control room.

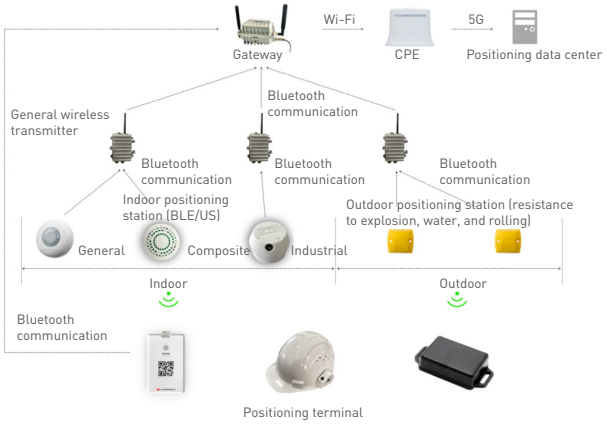


Bridge Crane Remote Control Solution in Yunnan Shenhuo Alumina Warehouse

07 5G-based positioning and tracking of personnel, vehicles, and fixed assets

Yunnan Shenhuo used to rely on extensive management of personnel, vehicles, and fixed assets, and delicacy management cannot be realized in the dynamic distribution of personnel, the movement of personnel, vehicles and assets, warning against unauthorized access to high-risk areas, and frequent absences.

The comprehensive positioning system that accesses 5G services through the perception layer consists of enhanced positioning system and positioning labels. A base station will send back the status and uplink/



Comprehensive Positioning System of Yunnan Shenhuo

downlink data of labels via communication channels between 5G gateway and positioning labels. The system allows to check the position and movement of personnel and trace and report safety accidents.

BENEFIT ANALYSIS

The plant will be a domestic model for traditional manufacturing transformation. Its success is of great significance to traditional industries.

1. Boosting production safety and quality:

• With 5G-based electrolyte leakage and energy consumption analysis, the plant can enhance delicacy management. It is estimated to save direct current of 100-200 kWh/t-Al annually. Along with optimized management, the annual saving will reach 90 million kWh after commissioning. The number of inspectors needed will be reduced by 90;

• 5G-based precision analysis of high-temperature molten iron can improve anode casting quality by 15%;
• 5G-based conveyor crack monitoring can reduce safety accidents and increase production efficiency. Inspectors needed will be cut by 2;
• 5G+MEC remote control of bridge cranes can minimize competition for the cranes and save labor costs by 60%.

2. Empowering safe production and technological upgrade

5G+MEC helps make production efficient and safe in the smart non-ferrous metal plant. Automatic production and smart management enable zero accidents in the production. When manpower is replaced by robots, smart management makes production safer and more efficient. New technologies can reduce O&M costs, optimize processes, and boost output.

3. Easy success case replicate and effective benchmarking effect

The success of the project can be replicated by other players engaged in aluminum electrolysis and non-ferrous metal smelting. The 5G+ Smart Plant platform builds the foundation for cooperation throughout the industrial chain. 5G slicing network allows enterprises' edge clouds to converge and connect via MEC.

REFLECTION

1. Success case

In building the 5G Smart Plant, Yunnan Shenhuo has fully considered smart production priorities and key areas in the construction of the smart non-ferrous metal plant to set up 5G MEC-based quality network and cloud-network environment where innovative applications can be deployed. Industrial Internet was utilized to connect all production and management elements. Capability interfaces have been provided to incubate various innovative applications that help reduce cost, increase efficiency, and optimize productivity. One-stop delivery and integrated design can not only meet Yunnan Shenhuo's immediate needs but also guarantee compatibility with future technologies. That makes the delivery of future projects and O&M easier.

2. Difficulties and challenges

1) Electronic equipment is greatly impacted by the strong magnetic fields in the electrolysis workshop.

Electrolysis workshop, core to an aluminum electrolysis plant, needs to operate with strong current. As a result, the plant is subject to irregular magnetic fields of high intensity, thus causing fault in electronic equipment. The workshop has several multi-function bridge cranes, which may cut magnetic lines and generate current during operation. Electronic equipment will also be adversely impacted. This poses a huge challenge to 5G CPE and industrial gateways with 5G modules.

2) Support for super uplink scenario and 5G module integration

Machine vision, remote bridge crane control, and other scenarios at Yunnan Shenhuo require high on uplink bandwidth. Yet there are few industrial cameras and SDI cameras equipped with integrated 5G super uplink modules. More effort should be invested to develop satisfactory products that meet specific demands.

3. Future planning

According to the "Two-Year Plan of 5G Smart Plant at Yunnan Shenhuo (2021-2022)", a 5G smart plant that focuses on key areas in non-ferrous metal production will be built in steps based on its comprehensive top-level design to meet the company and business demands.

A dedicated 5G network that takes into account the characteristics of aluminum electrolysis process will be set up, and it will include six modules: smart plant infrastructure, underlying platform for the smart plant, comprehensive smart information-based management system, industrial robots and smart equipment, smart production management system, and smart equipment O&M, security, and environmental protection system.

China Unicom Shandong 5G+ Smart Oilfield Solution in Shengli Oilfield

With an information-based production system, the oilfield has seen notable improvements in quality and efficiency, exploitation and management, and labor availability. Yet the system also poses higher requirements on the quality, safety, and stability of network communication. 5G and edge computing technology can ensure safe and reliable transmission of massive well data and reduce total costs in wide-area scenarios, and allow digital, network-based, and smart operation of the oilfield.

Xun Changzheng
Head of Information Center of Gudong Oil Production Factory at SINOPEC Shengli Oilfield

SOLUTION PARTNERS

OVERVIEW

The oil and gas industry is a pillar industry in China and a cornerstone of economic and social development. Gudong Oil Production Factory at SINOPEC Shengli Oilfield engages in oil-gas exploration, exploitation, processing, gathering, and transportation, with an annual production of 2.6 million tons of crude oil. To increase production and operation efficiency, the factory has, in recent years, adopted various networking solutions including fiber optic lines, 4G, and wireless bridges to build its information system. Notable improvements have been witnessed in quality and efficiency, exploitation and management, and labor availability. But with further exploitation and production, the current networking solutions fail to support the further development of the information system. The problems include inconvenient and costly installation of fiber optic cables, low uplink bandwidth of 4G network, and non-standard spectrum, imperfect industrial chain, and high maintenance cost of the wireless bridge. For this reason, the factory proposed building a smart oilfield with an upgraded production system that allows "real-time perception, comprehensive coordination, active management, and total optimization".

In November 2019, China Unicom Dongying Branch joined hands with Huawei and Gudong Oil Production Factory to develop the "5G+MEC" solution. In March 2020, the partners completed small-scale experimental verification of 5G network in the standalone (SA) mode and dedicated mode. On July 31, 2020, the three parties activated and verified 5G business in the SA and MEC modes and solved problems facing the traditional wireless bridge, fiber optic network, and 4G network in the backhaul of real-time well images and the transmission of production and control data. It can guarantee satisfactory bandwidth, time delay, and reliability, and support fast business launch. In the fourth quarter of 2020, the digital transformation of 438 wells

was completed. At the same time, "Pioneer 2 - DTU", an industrial 5G data terminal independently developed by China Unicom, was installed with external antennas. Applicable to various industrial scenarios, it can conveniently provide 5G access to industry users. A platform has also been built to provide convenient, flexible, and efficient management and services with China Unicom's 5G industry terminals.

CHALLENGES

In 2019, China's crude output edged up 0.8% year on year, registering a positive growth for the first time in the past four years. Yet a growth rate of 1.3% in operating revenue has hit a record low in four years. As global crude prices remain low, cost reduction and efficiency improvement has been the only way out for oil producers. For the moment, the oil and gas sector is faced with the following challenges:

1. A prominent contradiction between production shortage and surging demand for oil and gas
2. Oil companies are subject to production and operation pressure with rapidly increasing oil and gas investment and decreasing efficiency
3. Oil refineries have to deal with strict environmental requirements and substantial business loss.

SOLUTION AND VALUE

In the preliminary application of wireless bridge, fiber optic network, and 4G network, the factory has encountered many problems, for example, inconvenient installation of fiber optic cables, low bandwidth of 4G network (especially uplink rate), and non-standard spectrum, imperfect industrial chain, and high maintenance cost of wireless bridges. A 5G private network has solved the network maintenance and cost problems that have troubled clients for years. 5G technology is adopted to enable remote start and stop of low-output and low-efficiency wells. In 26 wells of different characteristics, 16 saw an increase in efficiency, with the average daily consumption reduced by 2.23 kwh/m^3 and an electricity saving of RMB 154,000.

01 Comprehensive solution of 5G private network

Wireless coverage

In the early stage, a 5G station was located at the north of the protection zone at the factory. According to the test model, a station can cover 200 wells within a radius of 2km. Another five stations were also planned to offer 5G coverage for wells north of the protection zone.

Terminal access

ZigBee communication protocol is still used for wireless pressure, temperature, and angular displacement sensors. Through RTU, ZigBee is translated into TCP/IP for DTU communication with 5G data terminals. Cameras are directly connected to DTU via TCP/IP protocol. China Unicom 5G SIM card is installed in DTU for 5G network access.

5G private network

In terms of 5G New Radio, service priorities are secured via 5QI, to be specific, 5G bearer via DSCP and 5G core network via QoS strategy formulation and management made for users. The solution allows 5G sharing with family and individual users. 2B business can be distributed quickly, without needing independent network planning. QoS solution requires zero network transformation and improves both user and business experience. As 5G matures and oilfields require more to serve complicated production scenarios, reserving 5G New Radio or RB, or even establishing an independent network, and communication network slicing via FlexE allow diverse 5G services to meet various uncertain business needs.

02 Implementation plan of 5G private network

As shown above, the data from wireless pressure, temperature, and angular displacement sensors is gathered via RTU, while cameras, DTU, and electric meters are installed on poles a dozen meters away from the well. RTU and cameras are connected to 5G DTU via twisted-pair cable, and the video image and sensor data are transmitted via DTU to the 5G network.

By deploying user strategy on the 5GC core network, the well data is forwarded via the 5G base stations to MEC in China Unicom Dongying Branch's network centers, instead of appearing in the data panel of common Internet users. Through the dedicated line between MEC and the oilfield monitoring center, the data is returned to the monitoring center's platform, while the data of common users follows default paths to enter the public network and access Internet data.

The product leverages the following communication edges of 5G:

- 3.5GHz band adopted boasts strong penetration in the open area and is less vulnerable to blocks;
- 5G bandwidth, which is significantly higher than that of 4G, allows continuous video and data transmission around the clock;
- 5G boasts short delay, stable signal, and high reliability;
- 5G terminals installed in the box can remain maintenance-free for a long time as it is less vulnerable to extreme weather, while the base stations are maintained by carriers;
- Positioning function allows an integrated appearance.

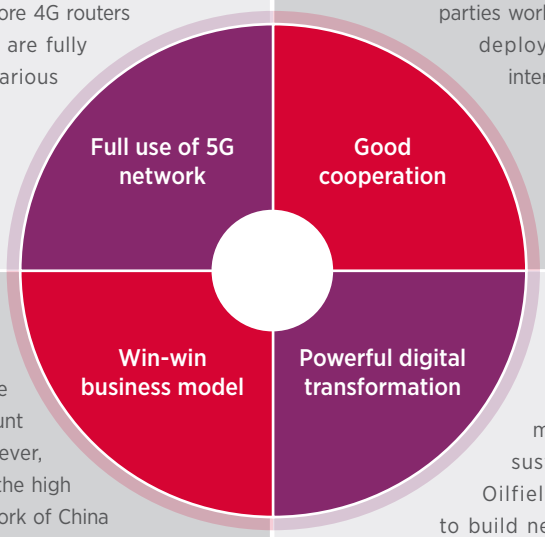
REFLECTION

The "5G+MEC" solution adopted for Gudong Oil Production Factory allows smooth backhaul of well monitoring image and production data, which were big problems when wireless bridges, optical fibers, and 4G were adopted in the past. E2E secures satisfactory bandwidth, time deal, reliability, and rapid business operation to meet expected goals.

The success is mainly attributed to:

Wireless bridge only supports short-distance transmission, which is vulnerable to interference and extreme weather. At the same time, wireless spectrum must be bought. As for optical fiber, the total cost is high and construction is difficult. In the case of 4G, the uplink peak rate is generally 8 Mbps. If many video images should be uploaded, more 4G routers are required. All advantages of 5G are fully exploited in the project to solve various problems.

The project is divided into three parts: network equipment (5G base stations and MEC) from Huawei, video surveillance and management platform from a third party, and self-developed 5G terminals from China Unicom. The three parties worked closely to complete network deployment through open network interfaces.



To maintain the network, the factory had to spend a huge amount of money every year, which, however, can be greatly reduced thanks to the high reliability of 5G network and the work of China Unicom professionals. The saving can be used to cover more wells. Through the project, more 5G base stations are built to expand the China Unicom 5G coverage in Dongying City. That means a better user experience and greater brand influence locally.

From 2014 to 2018, the factory launched and completed the digital transformation of seven management areas. Aiming at sustainable development, Shengli Oilfield started a campaign in 2017 to build new oil production management areas that feature digital operation, comprehensive systems, and clear responsibility assignment. By replacing wireless bridge with 5G terminals, the No. 1 and No. 2 Oil Production Management Areas have increased their production efficiency, reduced O&M work, cut the workload for employees, and facilitated the construction of institutions and mechanism in the company.

So far, the project has covered 438 wells. In 2021, another 700+ well will be transformed, and more than 2,000 will be covered and transformed in the next two years. After surveying the network in the factory, China Unicom Dongying Branch and Huawei are discussing the possibility of using 5G to transform the information system and make oil and gas transportation, storage, and processing smarter. The two will leverage advantages in network deployment, operation, ecosystem building, and local delivery and O&M to work closer and find more opportunities in smart geological prospecting and remote control through IoT and big data. Together, they will be the best duo in offering 5G+ Smart Oilfield solutions.

5G+ Smart Chemical Park of Dongying Port, Shandong

Shandong is taking the lead in China's chemical industry and Dongying Port Economic Develop Area (DPEDA) is the fifth largest chemical park in China. 5G brings an advantageous communication means for creating a safer and smarter chemical park. In 2020, DPEDA, together with China Mobile and Huawei, built China's first 5G+ smart chemical park, combining key cloud and AI capabilities for the verification of various application scenarios such as smart emergency response, smart safety supervision, and smart environmental protection. In the next phase, we will further expand 5G deployment and promote large-scale and in-depth verification of 5G+ smart chemical parks, creating a benchmark for the transformation and upgrading of the chemical industry.

Yang Tongxian
Secretary of Party Working Committee and Director of Administrative Committee of Dongying Port Economic Develop Area

SOLUTION PARTNERS DPEDA | 中国移动 China Mobile | HUAWEI

OVERVIEW

In March 2020, DPEDA brought together many suppliers including China Mobile Group Shandong Co., Ltd., Huawei, and Beijing Daheng, as well as key enterprises and emergency, environmental protection, fire, and safety supervision departments in the area, to effectively improve the management and control of the smart chemical park with the support of the modern information technologies to ensure the safe operation of the park. By integrating 5G, cloud, AI and other information technologies into various scenarios in the park, the 5G+ smart park solution is proposed in response to these needs, which focuses on the 5G private network, the enablement platform, and applications:

- In terms of 5G private network, Huawei and Dongying Branch of China Mobile Group Shandong Co., Ltd. have built more than 30 5G base stations in the development area. Continuous coverage of 5G networks has been achieved in key areas. To meet the needs of DPEDA for high data security and low latency, the solution deploys Multi-access Edge Computing (MEC) equipment in the park to ensure in-park data processing and access.
- Comprising of a data exchanging and sharing management platform, a video cloud platform, and an AI platform, the smart park platform supports data aggregation and connection with third-party applications by integrating various key technologies such as 5G, cloud, Internet of Things (IoT), and AI.
- In terms of applications, the solution covers many typical application scenarios involving 5G+ emergency command, 5G+ smart environmental protection, and 5G+ smart safety supervision in the intelligent management of chemical parks.

This project marks the industry's first comprehensive application of 5G, AI, edge computing, big data, IoT, and other information technologies in the intelligent upgrading of chemical parks. The project has been listed as a leading 5G+ demonstration project of China Mobile Group and a 5G+ safety production pilot demonstration project of the Ministry of Emergency Management of the People's Republic of China.

CHALLENGES

China is the largest market player in the global chemical industry and Shandong is the largest market player in China's chemical industry, housing a large number of chemical companies across the province. In view of the production safety, the biggest pain point of companies, Shandong Province is vigorously encouraging chemical companies to relocate from urban areas to dedicated parks. It required all chemical companies to complete the relocation to the 85 key chemical parks in the province as soon as possible, and put more than 120 companies under key supervision to improve the parks' information and intelligence levels. With these efforts, the province strives to build

chemical parks into main sites for undertaking chemical projects and fostering new growth drivers, so as to improve the concentration and safety levels of industrial development.

The updating and upgrading of communication technologies have become a key element during the evolvement of chemical parks into smart ones. The chemical field is a typical application of massive IoT. The large-scale chemical park of DPEDA will have millions of sensors to collect videos and other types of data at various production sites. Existing communication technologies for data transmission include optical fibers, 4G, NB-IoT, Wi-Fi, wireless bridges, and Near Field Communication (NFC). But they all have some limitations. By contrast, 5G allows more flexible and efficient deployment, supporting the transmission of site data in both broadband and narrowband scenarios such as park roads, junctions, construction sites, tank farms, damp-proof levees, and emergencies. Coupled with edge computing and the network slicing technologies, 5G private networks will be more efficient, safer, and more controllable than traditional technologies, being a better choice for addressing communication challenges in chemical parks.

Apart from updating and upgrading of communication technologies, the industry also faces a long-term pain point that the backend data processing is highly dependent on manual operations and lacks the support of next-generation information technologies such as AI. The park hopes to fully tap the comprehensive advantages of 5G technology to collect signals from millions of sensors and use big data and AI technologies for analysis and prediction, which can comprehensively improve the safety and management efficiency of the park.

SOLUTION AND VALUE

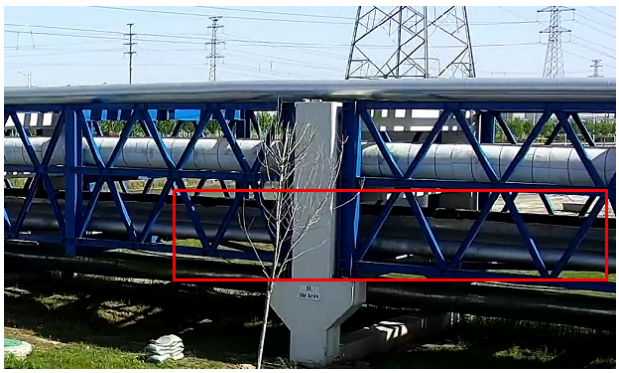
Based on the existing achievements of the DPEDA smart park, the solution transmits sensor data including camera-captured data back to the business processing system through the 5G network and uses cloud computing, big data, AI and other information technologies to store, manage, schedule, model, categorize, predict and analyze data. Leveraging intelligent data analysis and processing, plus the digital and integrated sharing service group of the smart park's data center, the solution combines the basic data, such as company profile, and the operational processes and mechanisms of various business modules of the command center to deliver early warnings and alarms on major hazards and monitor special operations in real time in production safety management, monitor and warn against hazards in public safety management, detect and trace pollutant emissions in environmental management, and monitor fire-fighting facilities in fire management and other business areas to achieve data collaboration and sharing. Meanwhile, drawing on the 3D GIS platform, early warnings and alarms in each business module can be more intuitively displayed on the map, facilitating the identification of problems for effective responses.

Scene of Dongying Port Emergency Command Center

In addition, the visual monitoring center enables data analysis and trend forecast, providing reliable data reference and decision-making support for government authorities and park management.

01 5G+ EMERGENCY COMMAND

With 5G+ drones, the solution transmits high-definition videos and statuses of existing emergency command vehicles in the park back to the smart dashboard of the emergency command center of DPEDA over the 5G network. Multi-purpose sensors are installed on existing fire hydrants to remotely monitor fire hydrants in Dongying Port in real time through the 5G+ IoT. Once a fire hydrant is intentionally damaged or someone fetches water against the regulations, an alarm will be reported immediately with the accurate location of the incident, so that inspection personnel can respond in a rapid and efficient manner. With electronic water level indicators installed, the park can quickly access the existing water resource data and show the geographical distribution of monitoring sites on a GIS map as well as the water level in a real-time floating form to prevent water supply shortage or failure during firefighting operations.



5G+ tunnel monitoring of Dongying Port

02 5G+ SMART ENVIRONMENT PROTECTION

5G+ mobile environment monitoring

With the 5G+ smart mobile monitoring system, sensors can be installed anywhere as needed, without limitations on the sensor locations. While efficiency and accuracy are guaranteed, the sensors can help monitor different construction environments in real time and evaluate the current environment safety, construction safety and environmental impacts.

5G+ odor monitoring

Through the 5G+ odor monitoring system and the park's early warning platform for safety and environmental protection, the solution enables full-coverage, all-weather, and full-process monitoring of the park's environmental safety. Revolving around prevention, early warning and safety, it can monitor the sources and trajectories of pollutants emitted by companies to ensure the safety of the park and its surroundings, improve the early warning and emergency response capabilities, and strengthen the park's management and control mechanisms for rapid responses to emergencies.

5G+ power usage monitoring of pollution control facilities

By monitoring the power usage of pollution control facilities, the solution can obtain the real-time load of pollution control equipment and compare it with the rated level to learn about the current operational statuses of the equipment. In this way, it can offer an insight to companies' compliance with the emission reduction and production trim regulations, and identify companies that discharge pollutants out of the emission limits, have poor control over pollution, or fail to meet the product trim standards.

03 5G+ SMART SAFETY SUPERVISION

5G+ major hazard monitoring

With the 5G+ major hazard detection system, the solution can automatically read, upload, and compare data at fixed time points, and automatically issue alarms on data abnormalities. This, while addressing the time- and effort-consuming manual meter readings, also avoids the circumstances where the inappropriate location of the meter causes difficulty or danger in manual reading.

5G+ tunnel monitoring

With the full-optical-fiber tunnel monitoring, the solution supports real-time monitoring, alarming, and positioning for tunnel vibration and temperature changes. Main equipment is monitored and connected to the monitoring center through 5G wireless routing network, so that the real-time status of the tunnel line can be displayed in the system.

04 5G+ SMART SAFETY SUPERVISION (PX PROJECT)

5G+ high-risk operation supervision

5G+ smart high-risk operation modules can be mounted movably and 5G camera-captured video streams can be analyzed in real time to alert supervisors to behavioral irregularities and high risks such as not wearing protective clothing or helmets during high-risk operations. Such real-time alarms on the platform can help improve the park's safety level.

5G+ electronic enclosure and smart construction sites

5G+ electronic enclosure and smart construction site modules can be made mobile to flexibly monitor hazardous information on the construction sites. This includes automatic identification of illegal behaviors such as intrusion into the construction site or high-risk areas, prompt and real-time reports and alarms, and sound and light alarms to alert field personnel, so as to eliminate unsafe factors and avoid casualties caused by the absence of personnel management.

5G+ smart safety monitoring

5G cameras can be mounted movably to supervise behavioral irregularities at construction sites of the park in real time. With the real-time analysis of the on-site environment, personnel, vehicles, etc. via AI technologies, the solution can automatically identify violations and highly risky actions at the construction sites, including illegal occupation of the fire evacuation passage, unauthorized crowd gathering, and unauthorized absence at key positions, and report and issue alarms in real time to remind responsible personnel to take immediate actions and reduce risks.

REFLECTION

The 5G+ smart chemical park features in-depth integration of 5G and AI technologies, which is of important significance for enhancing the safety, environmental protection, energy conservation and efficiency of the chemical park. The 5G technology supports full coverage throughout the park and real-time collection of information. The AI technology, on the other hand, realizes intelligent risk analysis and early warning, so as to lay a technical foundation for achieving "in-depth coverage, real-time monitoring, and effective control" of the chemical park.

1 Significance and value of 5G for chemical parks

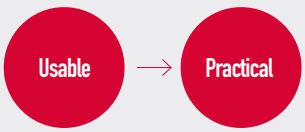
A chemical park has a large number of sensors and cameras to ensure production and facility safety. The current signal collection and transmission of sensors and cameras are based on optical fibers and DCS copper cables, with high costs and difficulties in construction and maintenance. The 5G technology features large bandwidth, low latency, and massive connections (millions of connections per square kilometer). If used together with Industrial Internet technology, 5G can achieve full coverage and real-time data collection, and hence gradually replace optical fibers and copper cables in the long run to cut construction costs of companies and parks. If every company cuts their costs by several millions or even several ten millions of RMB, the cost reduction for Shandong Province as a whole would add up to more than RMB 1 billion.

2 Significance and value of AI and big data for chemical parks

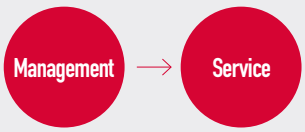
The introduction of AI and big data enables AI analysis and real-time monitoring and alarming of violations in key scenarios such as major hazards, monitoring rooms, and dangerous devices according to the operating specifications of the chemical park, thereby promoting standardized operations of parks and companies. Such efforts will translate to a higher degree of safety. The introduction of AI can also slash labor costs and improve efficiency and quality. Scenarios that require many manual efforts, such as tunnel inspections, hazard inspections, and various data collection and report preparation can be replaced using 5G+ AI. Such digital and intelligent transformation can save several millions of RMB in operation and maintenance for each park every year.

FOLLOW-UP PLAN

Despite the "Industrial Park" to "Smart Park 1.0" transformation of DPEDA, it marks just the first step from traditional informatization to digitalization, and there is still a long journey to go from being intelligent to being smart. In the next step, DPEDA will build on the existing achievements and take the initiative to build a demonstration model of the smart park.



First, promote the transformation from being usable to being practical. Horizontally, in accordance with the standards and requirements in Guidelines of Construction for Smart Chemical Parks in Shandong Province, DPEDA will deepen and improve the safety and environmental protection emergency system, accelerate the establishment of integrated services, energy and other systems, and achieve full coverage of management applications. Vertically, in view of its status quo, the development zone will promote customization of blind spot supervision in key areas such as ports and chemical industries to further enhance the park's modern governance capabilities.



Second, promote the management-to-service transformation. DPEDA will promote the transition from "Smart Management" to "Smart Service" toward the goal of "Smart Park 2.0". On the one hand, with the "technical reform in thousands of companies" as the starting point, DPEDA will accelerate the construction of smart factories and promote traditional manufacturing to extend to the higher end of the smiling curve. On the other hand, by building a smart park, DPEDA will connect the entire industrial chain with the industrial IoT, and speed up the construction of the logistics center to closely integrate the secondary and tertiary industries.

Ningbo-Zhoushan 5G Smart Port

The 5G technology has triggered great changes in gantry crane operations. The drivers can now work in the air-conditioned office for remote operation instead of working the 20-meter-high control room; the handling efficiency increases by 20%, the overall human resource cost is more than halved, enabling umanned operation, and improving safety.

Hu Houkun
Vice Chairman of Huawei

SOLUTION PARTNERS

NINGBO ZHOUSHAN PORT 宁波舟山港 | 中国移动 China Mobile | HUAWEI

OVERVIEW

Ningbo is a famous international port city. Its port, the port of Ningbo-Zhoushan, is among the busiest ports in the world. Port is like a barometer of the economy, the blood of the modern economy, and plays an important role in promoting international trade and regional development. About 90% of global trade is made through shipping, and port is a key link in shipping.

11.19 billion tons
Cargo Throughput in 2019

2753+ million TEUs
Container Throughput in 2019

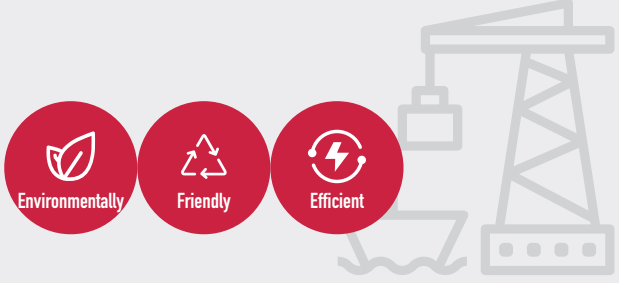
Ningbo-Zhoushan Port is one of the main hub ports in China. Its cargo throughput has ranked first in the world for 11 consecutive years, reaching 1.119 billion tons in 2019, and its container throughput ranked third in the world, exceeding 27.53 million TEUs in 2019. It is an important ocean-going container shipping port on the trunk line, and the largest iron ore transfer base and crude oil transfer base in China.

On May 15, 2020, Zhejiang Seaport Group, China Mobile Zhejiang Company, Shanghai Zhenhua Heavy Industries Company Limited (ZPMC) and Huawei Technologies Co., Ltd. jointly signed the Ningbo 5G + Smart Port strategic cooperation agreement to build a global demonstration port of normalized 5G-based smart operations to serve the goal of building a world-class port.

CHALLENGES

After years of development, Ningbo-Zhoushan Port is under tremendous pressure for cost reduction and efficiency enhancement. It hopes to utilize 5G, AI, cloud and other digital technologies to create an "environmentally friendly and efficient" smart port to quickly transform its operations.

It is worth noting that the port has a strong demand for efficiency improvement. Efficiency is essential in port operations. The rent of a large ship can amount to several hundred thousand US dollars a day. An extra hour of waiting or operation can waste tens of thousands of dollars. Therefore, important ports like Ningbo-Zhoushan Port have been quite demanding on operation automation and efficiency while ensuring all-weather and continuous operations throughout the year.



SOLUTION AND VALUE

The 5G smart port project of Ningbo Port currently highlights three applications: 5G-empowered smart tallying, automatic logistics of 5G-empowered unmanned container trucks, and 5G-empowered remote control of tire cranes.

01 5G-empowered smart tallying: This can improve the working environment and ensure safety, in addition to improving the tallying accuracy and efficiency.

Tallying efficiency has a direct bearing on the efficiency of container terminal operations. At a 5G smart port, 5G-empowered smart tallying means that HD cameras are installed on quay cranes to transmit data over the 5G network. The smart tallying system can automatically identify container numbers, container types, operation number of in-terminal container trucks, the weighing positions of single small containers, and lane numbers among other data and statuses. The identification has an accuracy rate of more than 95%, and the data and status of a container truck can be identified within one second, without affecting the container handling progress.

5G enables three improvements in smart tallying:

- Environmental improvement: Transform from on-site operations with harsh conditions to remote operations in comfortable offices.
- Efficiency improvement: Transform from "one operator for one quay crane" to "one operator for multiple quay cranes". It is estimated that Ningbo-Zhoushan Port can save about RMB 17 million of labor cost per year.
- Identification accurcay rate improvement: High-definition images combined with AI-based machine vision can achieve an accuracy rate of more than 95% even for damaged box numbers.

Technically, it needs 30-50 Mbps of bandwidth to upload 15 channels of real-time smart tallying videos for each quay crane. This requires the use of 5G's high bandwidth and low latency features as well as the MEC (Mobile Edge Computing) technology for quick image recognition.

02 5G-empowered automatic logistics of unmanned container trucks: Logistics have been automated throughout the process, which improves the transportation efficiency and safety.

Self-driving trucks are used for the 5G-empowered automatic logistics at a modern port. The 5G-empowered unmanned container truck has a super "5G + AI brain". After the quay crane loads the containers and confirms that the truck is correct, the unmanned truck will automatically set off just like a veteran driver, identifying surrounding containers and objects, mechanical equipment, lighthouses, etc., and autonomously making decisions such as slowing down, braking, turning, detouring, and stopping in various circumstances. The truck can follow the optimal route to move to the designated position for the tire crane to handle containers, meeting the horizontal transportation needs in the enclosed areas of the port.

With 5G unmanned container trucks, horizontal transportation can be automated without major transformation. In the future, unmanned container trucks will support remote control. When a truck fails in the operating field, the operator can check the surrounding environment through cameras, troubleshoot problems, and remotely control the truck to leave the faulty area.

5G-empowered unmanned container trucks highlight two major improvements:

1. The solution has effectively reduced the efforts and costs of manual operations. Taking Meishan Port as an example, there are about 800 drivers in three shifts operating more than 200 in-port container trucks. The number of drivers is 300 more than the number of Meishan Port's regular employees. The cost per driver is RMB 120,000 per year, totaling RMB 100 million per year.
1. The solution has addressed the problems of driver shortage and driver fatigue, improving operational efficiency, reducing safety risks, and achieving all-round upgrading and transformation of the port from a labor-intensive industry to an automated, intelligent, and unmanned one.

It needs at least four HD camera channels to achieve remote control of unmanned trucks, and the network must reach 20-30 Mbps/unit for uploading and a latency of < 20 ms. The 5G technology is born to support such applications.

03 Remote control of 5G-based tire cranes: Driver's efficiency increases by 3-4 times

5G-based tire cranes are already used for normal operation at Ningbo-Zhoushan Port. With 5G-based remote control, workers can sit in the central control room and watch the multi-channel real-time videos transmitted from the cameras over the 5G network. Most of the operations have been automated. Only the container lifting operation with crane spreaders requires manual remote intervention. In the past, one operator can only control one tire crane. But now, it is easy to control three to four units at a time, greatly boosting the work efficiency.

Ningbo-Zhoushan Port has completed the transformation of six tire cranes and a series of production verifications such as low-latency reliability testing, long-term durability testing, and concurrency testing of multiple tire cranes for more than a year, and is the first port to embrace normalized operations of the 5G-based automation. The existing 5G network has an average end-to-end latency of 8-10 ms, with the PLC control reliability reaching 99.999%. In the future, the new uplink-enhanced solution of China Mobile can bring the uplink bandwidth to 1 Gbps to meet the needs of tire cranes, bridge cranes, unmanned container trucks, video surveillance and other port services.

REFLECTION

In the past two years, the 5G-based smart port development of Ningbo-Zhoushan Port has been progressing in an early, fast, and solid manner.

Early Adopter: Ningbo-Zhoushan Port has been promoting 5G network coverage and application trials since 2018. In September 2018, China Mobile Zhejiang and Zhejiang Provincial Seaport Investment & Operation Group Co., Ltd. signed a 5G smart port strategic cooperation agreement to build China's first 5G port base station in the Meishan Port Area of Ningbo-Zhoushan Port.

On April 16, 2019, before China's 5G was officially licensed, Ningbo-Zhoushan Port recorded a success in piloting wireless information application innovation based on the China Mobile 5G network, including remote gantry crane operation management and video transmission, making the port the first in China to implement 5G applications.

Moving Fast: Ningbo-Zhoushan Port now has full 5G network coverage. It has converted 5G demonstration cases to practical deployment and use, with its port efficiency increased and its operation and maintenance costs of the communication system reduced.

Ningbo-Zhoushan Port has recorded three firsts in application of the 5G technology industrywide.

It is the first in the industry to complete remote operation verification and normalized operation of 5G-based tire cranes. The port has completed the transformation and verification of six 5G-based tire cranes, and verified that 5G can simultaneously meet the high uplink bandwidth and stable low latency needs for remote control of multiple tire cranes.

It is the first in the industry to apply 5G network slicing to ensure SLA for important port services. The port has deployed 5G RAN, bearer network, core network, industrial-grade CPE, CSMF (communication service management function), NSMF (network slice management function), and other end-to-end network slices to build the first 5G shopping center, supporting 5G smart ports.

It is the first in the industry to support end-to-end 5G uplink-enhanced solutions, meeting the high uplink requirements of tire cranes, container trucks, video surveillance, bridge cranes and other port services. The project was the first to complete the innovative 5G uplink-enhanced solution verification at Ningbo-Zhoushan Port. Leveraging the 2.6 GHz TDD spectrum and 1.8 GHz SUL spectrum, the project enhanced the uplink capacity of commercial 5G networks and supported China Mobile Zhejiang in leading status for the 5G City project.

Tests have shown that this innovative uplink-enahcned solution can use the 2.6 GHz and 1.8 GHz spectrum resources to record an uploading speed of 310 Mbps or higher per user. Within the network coverage, the overall uploading rate is increased by 30% to 100%, enough to support 9 tire cranes and meet the current port service needs. At the cell edge in particular, the uploading rate is increased by two to four times, greatly boosting the cell edge uploading performance.

Solid Cases: the 5G technology has been listed as an important development focus in this year's new infrastructure policy. 5G-based smart port is one of the seven major industry applications that the "new infrastructure" focuses on. The policy have benefited Ningbo-Zhoushan Port.

The commercial launch of the 5G smart port at Ningbo-Zhoushan Port has remarkably cut the cost and enhanced the efficiency, showing the great value of 5G for empowering every industry. In the future, we will call on the industries to cooperate closely and use the advanced 5G SUL uplink enhancement and other innovative technologies to keep commercializing the 5G smart port industry at scale globally.

Ericsson Nanjing 5G Smart Factory

By embracing smart manufacturing and Industry 4.0, the Ericsson Nanjing factory will achieve improved quality and efficiency, while supporting our goals to improve sustainability within the supply chain. The Ericsson Nanjing site plays an important role in the Industry 4.0 strategy at Ericsson Supply, creating use cases with local business value for scaling within the global New Product Introduction & Production community.

Charlotte Fenton
Head of Ericsson Supply China

SOLUTION PARTNERS

ERICSSON | 中国移动 China Mobile

OVERVIEW

As Ericsson's largest "new product industrialization center" in the world, Ericsson Nanjing factory is a key enabler of Ericsson's global digitalized ecosystem and plays a leading role in transformation of smart factories towards 5G and Industry 4.0. Besides, the pioneering new ICT and flexible automated manufacturing technologies have been put into use in Nanjing factory, which also empowers other Ericsson sites around the world.

In November 2019, Ericsson Nanjing factory launched 5G Smart Factory project with partner China Mobile Jiangsu. In early 2020, the first commercial 5G physical private network in Jiangsu province was built, covering an area of 10,000 square meters, including multiple shop floors and warehouses. By the end of 2020, over one hundred of IoT devices were connected in 5G network.

In early 2019, Ericsson Nanjing factory set its objective of "Industry 4.0 strategic transformation". Relying on 5G smart manufacturing technologies, Nanjing factory aimed to improve its productivity, sustainability, flexibility, and quick response to market demands via digital transformation. And the Smart Manufacturing Department was setup in early 2019 to promote factory digital and intelligent transformation.

Apart from the organization, roles, and processes, smart manufacturing architecture is another area that requires transformation. Drawing on the Industry 4.0 system architecture, Ericsson Nanjing factory designed the entire 5G Smart Factory architecture which combines 5G private network, Industrial Internet of Things (IIoT) platform, and 5G applications, The architecture is the core engine that drives the factory's digital and intelligent transformation.

CHALLENGES

There are three main challenges in the transformation towards Industry 4.0:

Increasing market demand for new products in different types and small batches and production is less flexible.

Production costs need to be further reduced, and product quality requirements are higher.

Factory urgently need to upgrade the level of automation and digitalization to increase efficiency and transform into data-driven enterprise.

SOLUTION AND VALUE

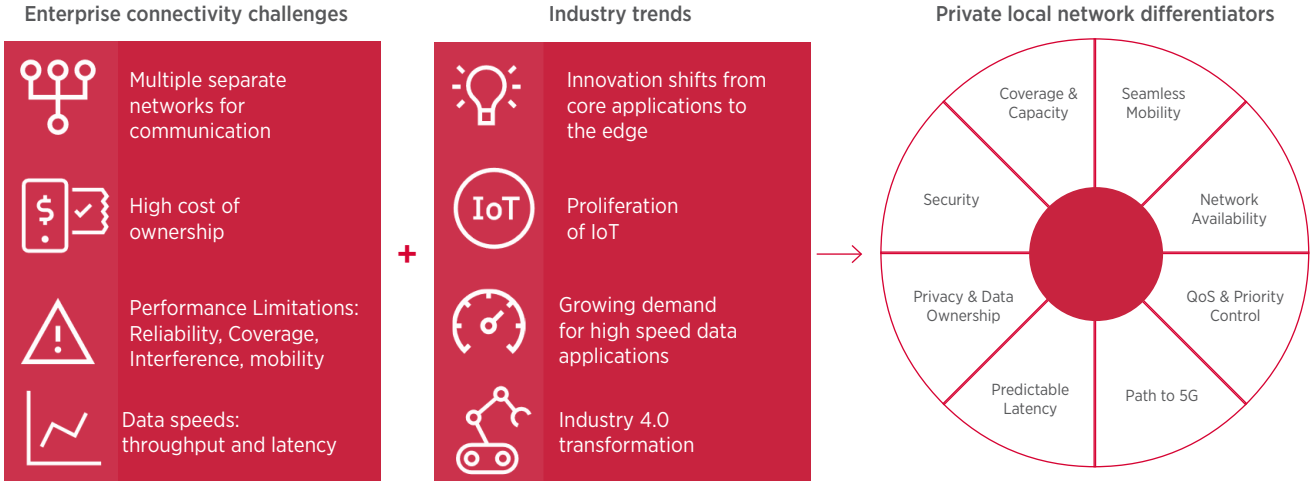
01 Network Solution

Network challenges

- Multiple networks existed in factory. This leads to high total cost of ownership and limited network capabilities.
- Factory digitalization, rapid growth in IoT connections, and new applications require a high-speed, mobile, and reliable network infrastructure.

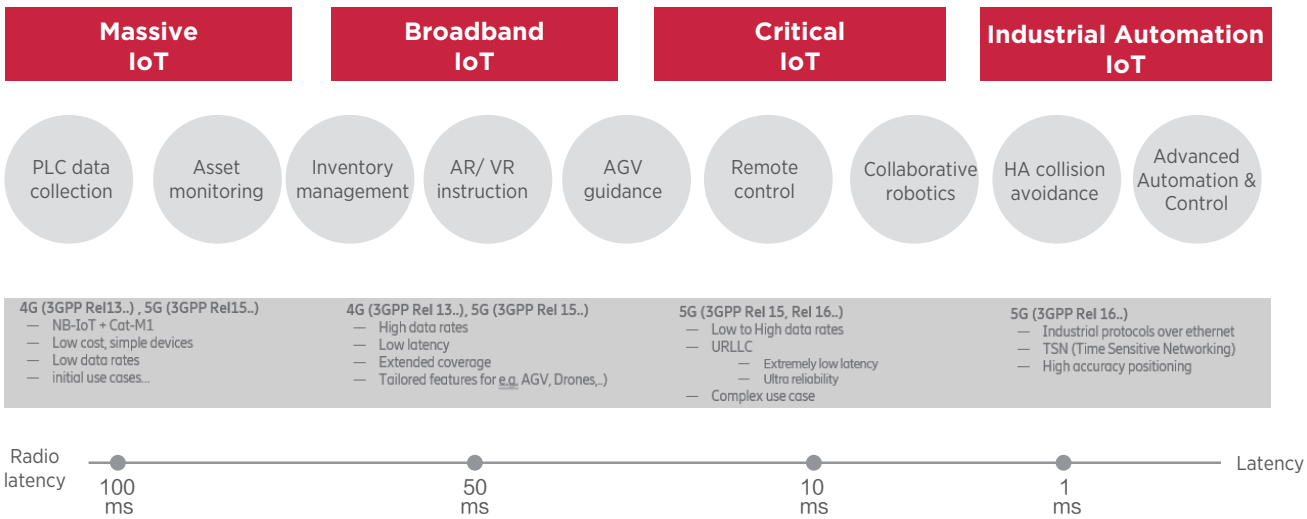
Factory for choosing a next generation network

- Despite the SWOT analysis of the existing network, most factories hope for improved mobility (flexibility), availability, QoS, priority control, predictable latency, better privacy data ownership and increased security in the next-generation network. Such network should come with wide coverage and capacity without blind spots, and can be accessed by the existing IoT devices and those deployed within the next 5-10 years.



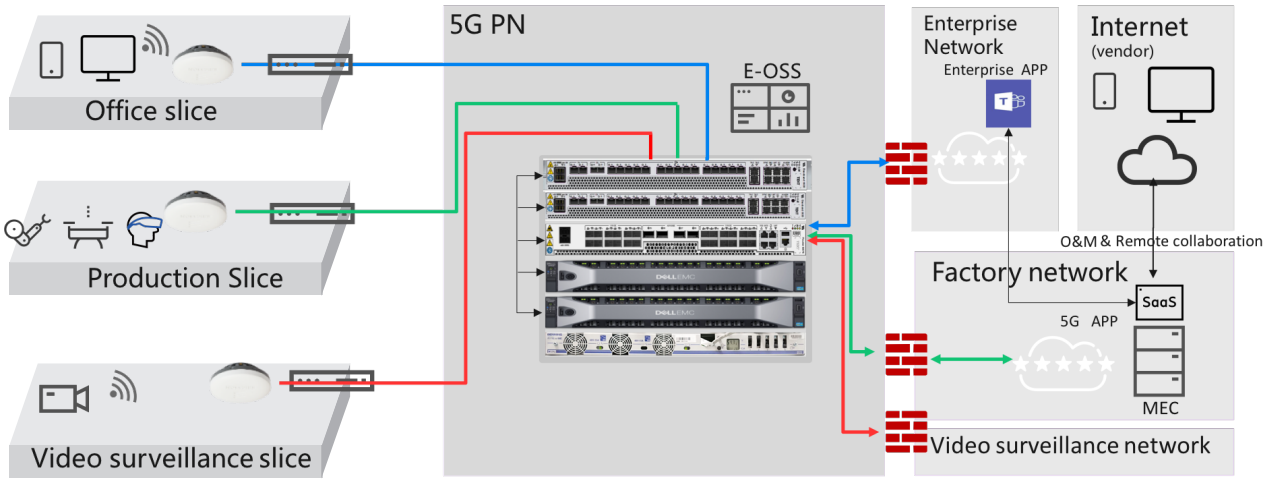
Why 5G: Choosing the 5G private network in Ericsson Nanjing factory

The 5G private network supports massive IoT and broadband IoT such as connections for data collection, asset sensors, inventory management, AR/VR, and AGV. When 5G network new versions get rolled out, critical IoT and industrial automation IoT connections such as remote control, collaborative robots, anti-collision, and advanced automation control will be supported in the future. Within the next 3-5 years, the 5G private network will basically support all IoT service demands, with its high mobility, broad coverage, and high QoS, and therefore completely fulfilling the next-generation enterprise network requirements.



The long-term planning of the internal network of Ericsson Nanjing factory will be integrated and evolved with the 5G private network.

Based on a set of 5G private network infrastructure, it provides multiple network slicing capabilities in production, office and monitoring scenarios, and realizes the connection and data isolation with different terminals, effectively reducing the overall cost. During the implementation and operation process, the project team and the factory IT department deeply discussed the role of the 5G private network. The factory IT and other departments gradually recognized that the 5G private network can be used as the core of the factory intranet, which marks the accelerated transformation of the factory's intranet to cellular and 5G network. The 5G private network will greatly reduce the number of networks in the factory's intranet in the long term, simplify network operation and maintenance, and shift towards cellular production and operation, thereby comprehensively improving the level of mobile IoT and flexible production in the factory, accelerating equipment networking and promoting business development. This is a domestic commercial project that has been deeply involved in the field of 5G physical private network and is well integrated with the corporate intranet.



02 Platform Solution

The IIoT platform is a software system powered by Ericsson Nanjing factory, which improves existing operation technology (OT) scenarios to data-driven business and bringing the software system into cloud. The rapid developing IIoT can quickly connect, people, machines, and devices to the network, eliminating the information isolation and gathering massive data. IIoT also provides big data and AI support for applications, facilitating the data utilization of design, supply chains, and customer, promote business innovation and process digital transformation.

IIoT platform fulfills devices and production process requirements, and also ensure data security. It is the core engine for the factory's Industry 4.0 transformation. Nanjing factory keeps continuous communication with other Ericsson sites to share experiences with the IIoT platform and promote the technology successful use cases to other factories.

03 Use Cases

Ericsson Nanjing factory had developed multiple types of cellular network-based industrial applications (i.e. smart screwdriver and Andon system) since 2018 and had developed over 10 use cases in 2020, covering various fields in smart factories. The following shows the 5G use cases in the factory:


5G cloud AGV Scheduling System

5G cloud AGV Scheduling System

AGVs moves a large volume of raw materials and finished goods in production workshops. The 5G network resolves the problems of network latency and disconnection from traditional Wi-Fi networks. By using low-latency and high-quality network, AGVs can operate with stable connection, ensuring high device utilization and uninterrupted production.

By integrating the private cloud of the factory with 5G private network, multiple types of AGV scheduling can be deployed on the cloud, which can implement remote troubleshooting and software upgrading. In the future, AGV system can be connected with the enterprise's Manufacturing Execution System (MES), then the material and status information can be displayed by visualization platform. This will improve the digitalization of factory logistics and help enterprises implement data-driven decisions.


5G AR Remote Expert Guidance

AR Training and Remote Expert Guidance

Every year, the factory introduces a range of new products and has mature products transfer projects, and each project involves product training and employee business trips, which take a lot of time, consume materials and compromise productivity. Furthermore, business trips are subject to environmental constraints, which may affect project lead time.

In this case, Ericsson Nanjing factory uses 5G AR training and 5G AR remote assistance technology to solve above challenges. By using AR technology for digitalized and modularized training programs for new products, factory provides a simple and intuitive understanding of operations to employees. The training content and results are synchronized to the management system via 5G network, making it easier for analysis. It greatly reduces the training time, minimizes production line downtime due to training and improves training quality. In addition, 5G AR enables multi-person remote collaboration across multiple locations. Real-time video connection and multi-person high efficiency communication will greatly reduce business trip costs and improves efficiency and also fulfill project lead time.


5G Drones for Inventory Counting

5G Drones for Inventory Counting

Factory uses 5G drones automatically inventory counting. Drone uses cameras to scan labels and transfer data automatically to controller via 5G network. Drone solution can greatly improve efficiency by over 50 times. Original, it used to take about 1.5 days to complete inventory counting with one person in a single area. But now, with 5G drones, it only takes 15-20 minutes. Drone solution not only improve efficiency, but also reduces inventory discrepancy.


5G wireless Industrial PCs

5G wireless Industrial PCs

There are a lot of industrial PCs in factory for product information collection. Traditional fixed networks required rewiring during production layout change, and it may take a long time for cabling, which impacts productivity and waste labor and material costs. Furthermore, factory needs expend wired cables annual maintenance costs.

By virtual of high quality and large bandwidth of the 5G network, factory replaces the original wired industrial PCs to 5G wireless solution, it improves the rapid deployment of production workshops and device access capabilities, greatly reducing labor time and costs. By using UPS at the same time, the layout adjustment of key positions can ensure productivity and improve efficiency without having to cease production.

REFLECTION

1. UPF+MEC is a popular 5G 2B network solution in China. Ericsson Nanjing factory adopts a commercial 5G private network, which is no often seen in China. It is a true implementation of a private network and enterprises can rely on the 5G private network to upgrade its existing network.

2. Lots of 5G projects focus on the network and use cases. Ericsson Nanjing factory also focuses and invests on development of the IIoT platform. IIoT platform plays as the core engine of Industry 4.0 and an important part of 5G use cases.

3. All factory 5G use cases come from Smart Manufacturing department and various business departments cooperated investigation. 5G use cases should strictly adhering to business value, then they can be successful deployed.

5G-Connected Flexible Production Line of Guizhou Tyre

The fusion of 5G and production has remedied the limitation of traditional industrial wireless intranet. This enables a smoother production line process and a clearer picture of how the materials flow, providing new ideas for production efficiency enhancement. By deepening the integration of next-generation information technologies represented by 5G with manufacturing for quality improvement, cost reduction, and efficiency enhancement purposes, we can further fuel the high-quality development of the company.

Wang Kun
Deputy General Manager of Guizhou Tyre Co., Ltd.

SOLUTION PARTNERS

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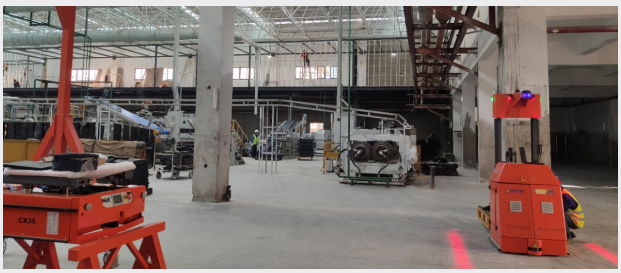
OVERVIEW

Guizhou Tyre Co., Ltd. is a leading OTR tire company in China and one of the national OTR tire production and export bases. More than 50% of its products are exported overseas. In 1996, it was listed on the A-share market with the stock abbreviation of "Qian Tyre".

In August 2020, Guizhou Tyre joined hands with related industrial equipment manufacturers to launch the "5G-Connected Flexible Production Line" project based on its innovative production line by leveraging China Unicom's cloud-network-edge-terminal full-process solution and Huawei's 5G network technology. The core 5G private network transmission technology can support a complete production line, achieving all-process and all-scenario wireless industrial interconnection and production scheduling. With the data of each production procedure being recorded and monitored in real time, the 5M1E factors required for the production of a digital factory - Man, Machine, Material, Method, Measurement, and Environment - can hence be interconnected for easy control and management.

This project uses the 5G wireless technology and MEC platform instead to connect 90 sets of multi-purpose AGVs, 50 sets of RFID sensors, and industrial cameras. This new approach allows extremely dense terminal access and provides a high-security SLA, addressing the WiFi access bottleneck that has plagued the company, and enabling flexible arrangement of production line factors, thus enhancing production efficiency. This project has also tested AGV management application based on China Unicom's MEC system, making a useful attempt to promote the 5G technology in industrial manufacturing processes. Currently, the 5G adaptation test and verification of AGVs and RFIDs have been completed, and a new 5G AGV adaptation and transformation plan for the industry is in the pipeline to incorporate visual inspection, remote control, and human-vehicle-thing collaboration capabilities over a 5G private network.



CHALLENGES

Guizhou Tyre industrial facilities occupy large-scale industrial campuses with a single production workshop covering 100,000 square meters. The facilities mainly produce tires for large engineering vehicles. As product iteration becomes faster and product categories are diversified, the existing production lines are put under pressure to manufacture more categories at a higher quality level. This calls for strong flexibility of production lines. In its efforts to achieve flexible manufacturing and lean production, the company faced two challenges: network transformation and flexible arrangement of production lines.

1. Complex network conditions

- Co-existence of multiple networks: The factory deployed a variety of networks and transmission methods such as Ethernet, WiFi, and

ZigBee. Such a situation made adaptation and conversion difficult, and required high costs for planning, construction, maintenance and optimization.

- Poor Ethernet scalability: The network was based on the traditional wired Ethernet, which needed costly and time-consuming maintenance and reconstruction.
- Insufficient WiFi network performance: The complex steel structures in the workshops interfered with the signals which made terminal roaming difficult.
- Low transmission security: WiFi connections are generally subject to serious security vulnerabilities which might cause risks to production.

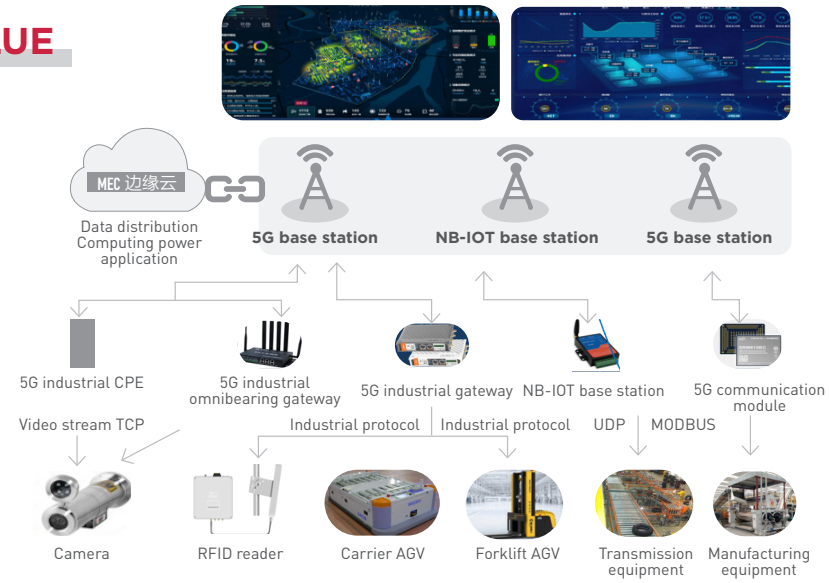
2. Difficulties in flexible arrangement of production lines

- Lack of information collection: Real-time statuses and control information of various processes in a production line needed to be collected. This required access by a large number of AGVs, RFID-aided material sensors, surveillance cameras and other devices. The existing network was unable to handle such a high device access density.
- Existence of information silos: There were multiple information system platforms in the factory for material management, AGV management, production execution, and quality management which were isolated from each other. The inconsistent transmission methods and isolated computing and storage devices made coordination and scheduling difficult, resulting in backlog of raw materials and low utilization of production lines among other problems.
- Low system scalability: As products get iterated and upgraded, the production lines must be expanded and transformed accordingly. All the existing subsystems including Ethernet, WiFi, IPC, PLC, and SCM were isolated and none of them supported flexible scalability.
- Costly system maintenance: The control systems of Ethernet, IPC, PLC, SCM and other subsystems of the production lines needed to be developed and managed by talents from different disciplines, with long development cycles and high operating costs.

To sum up, Guizhou Tyre must build a high-performance, scalable, and maintainable converged network and a computing platform in order to establish flexible production lines. The solution of 5G private network and on-site MEC can provide a highly stable, reliable, and safe wireless local area network that breaks information silos and supports multiple access methods and numerous device connections to ultimately achieve cloud-network-edge-terminal collaboration. This perfectly fits the flexible manufacturing and lean production requirements of the company.

SOLUTION AND VALUE

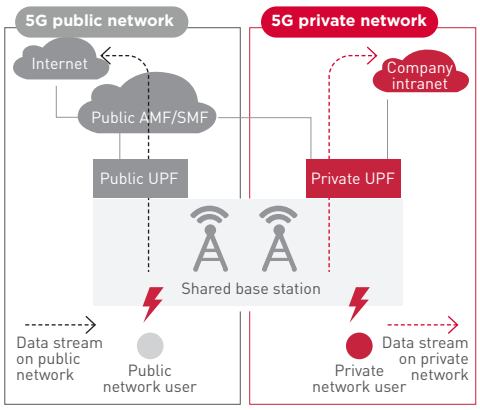
Based on actual scenario requirements and business bottlenecks, the manufacturing industry and the communications industry should complement each other's advantages by leveraging the integrated application of the 5G technology to achieve intelligent, collaborative and efficient operations of production lines. The aim is to provide innovative values and scenarios for 5G application in industries, spurring deep integration of 5G and industrial manufacturing, and contributing to the upgrading of traditional manufacturing.



01 5G private network in place of traditional Wi-Fi network

Throughout the tire manufacturing process, AGVs were connected over a WiFi network. However, since a workshop covers an area as large as 100,000 square meters, the WiFi network suffered weak coverage, unstable signals, poor security, difficult operation and maintenance, and poor scalability among other shortcomings. The unstable underlying network for wireless transmission then resulted in hidden dangers and low efficiency of the production line.

To ensure data separation in the campus, independent and controllable management of data as well as network scalability and compatibility, the 5G+MEC hybrid private network has been adopted in place of the WiFi network across the factory for wireless transmission. The hybrid 5G private network is a basic network with enhanced bandwidth, low latency, and localized data on campus built based on the 5G data distribution technology through flexible customization of wireless connections and network control elements. The user plane network elements UPF/MEC are deployed on privately hosted servers,



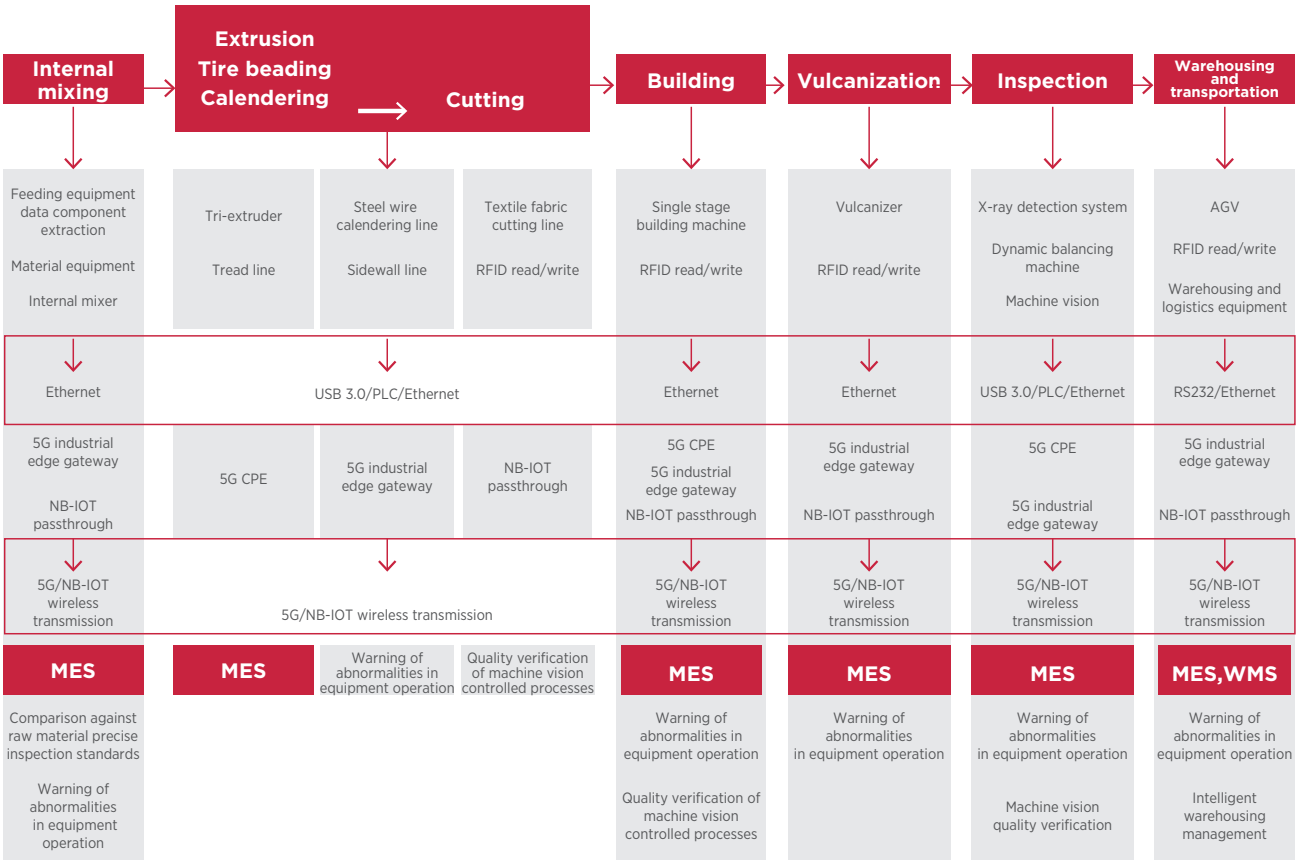
and the wireless base station is flexibly deployed according to customer needs. Some physically-exclusive 5G private network slices are provided for AGV and RFID systems to ensure low-latency and seamless connections of AGVs while shielding public network impacts on manufacturing processes, so as to enhance the manufacturing safety of the flexible manpower line.

Meanwhile, a production-site MEC service platform is deployed, with an AGV dispatching system and a video algorithm system deployed on the MEP. The AGV control data is transmitted directly to the MEP server through 5G network for processing and dispatching, and thus on-site IPCs are reduced. Apart from shortened latency, this solution supports applying on-site computing power to MEC to address network performance and scalability. It ensures the integrated development of multiple systems at Guizhou Tyre, and further enhances line flexibility to accommodate diversified production at a lower cost.

A stable neural network system featured wireless transmission constitutes the base for building an intelligent factory and can improve the consistency of inter-system data transmission and analysis. The low latency allows systems to collaborate closely, the extensive connection provides the redundancy to accommodate more devices, and the network interface consistency lays the foundation for flexible system expansion and upgrading to cut the cost.

02 5G multi-system integration and flexible collaboration

According to the production processes of the tire factory, the RFID systems and AGV systems have been upgraded wirelessly over the 5G network. The uniform network ensures efficient data interaction and integration, so as to ultimately enhance collaborative production in the factory.



A total of 50 RFID systems have been deployed in various tire production processes throughout the line. RFID systems can trace the production progress and status of products in each process in real time, and dispatch and manage AGVs and other production lines through the MES/MOM system.

A total of 90 AGV systems have been deployed throughout the line, covering rubber mixing workshop, components workshop, building workshop and mold warehouse. There are various types of AGVs in the factory to meet different needs of processes. Therefore, execution coordination should be guaranteed by a stable and reliable transmission system and sensing system.


Tread (all-steel)


Inner liner


Sidewall


Tread (semisteel)

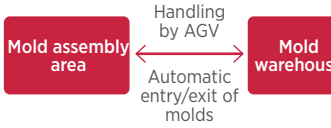

Belt


Bead

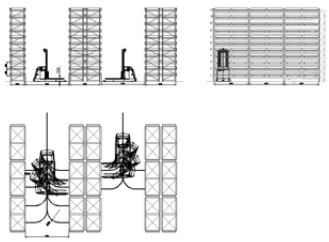
03 5G equipment integration breaks protocol boundaries

The AGVs used by Guizhou Tyre are of a foreign brand and are subject to transmission protocol identification. If a traditional transmission method is used, it will be very difficult to expand and upgrade systems. The 5G industrial gateway based on Linux open-source system is used to connect the AGV information transmission interface to collect the raw operation data of AGVs. After secondary encoding, the data is transmitted over the wireless+private network link composed of 5G base station, 5G industrial gateway and private network system, which features low latency, large bandwidth and high stability. The "1*N" method is adopted for transmission of operation data, that is, one signal is transmitted with multi-frame redundancy, to improve system stability to some extent. The redundant signals are transmitted to the AGV native dispatching system after pre-analysis and processing by the platform to support AGV dispatching in the workshops. The direct transmission of native system operation data addresses the inability to collect data or incomplete transmission caused by an unidentifiable protocol format, and the resulting failure to support normal functioning of the dispatching system. Meanwhile, the redundant transmission of signals and the redundancy judgment mechanism can also improve the system operation reliability. Backed by the powerful data transmission of the 5G private network, this approach can ensure an information transmission latency of about 20ms between AGVs and the dispatching system, which fully meets the business needs. This approach addresses the underlying data transmission protocol adaptation in industrial scenarios, greatly enhancing the equipment compatibility for 5G transformation and breaking the barriers to upgrade traditional production equipment. It offers a low-cost and easy-to-deploy solution for 5G application.

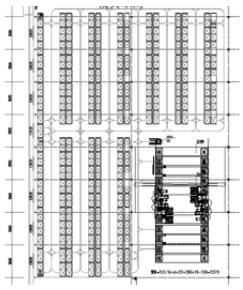
The 5G-connected flexible production line of Guizhou Tyre can not only improve production efficiency, but also predict equipment operating conditions. With the operation and maintenance costs cut by nearly one-third, it helps achieve agile flexibility of the flexible manpower line and speeds up line adjustments to accommodate the production of different tires. It is expected that the solution can help the factory record a sales income of RMB 120 million and increase the production capacity by about 120,000 tires. This solution now has been applied to the 5G + MA series hydrodynamic transmission assembly line in Guizhou Winstar Hydraulic Transmission Machinery Co., Ltd and other projects.



Stacker FX30 is used to handle, transport and warehouse molds in and out of the warehouse The rack has 11 stories and is 7 meters high, with 3,400 positions



Mold workshop



REFLECTION

The purpose of the 5G-connected flexible factory is to realize automated, digitalized, model-based, visualized, and integrated production and manufacturing with scientific decision-making. Combining the solution with the production management system that covers the whole factory, the company can monitor and adjust the entire production process in real time. For digitalized production, the company can use the factory-wide internet platform to interconnect machines and people, so that production data can be collected by production managers in real time to perform stringent management over the site. The fully-connected flexible factory empowered by the 5G private network can connect up production equipment as well as design, procurement, warehousing, logistics and other processes, so as to enable a flattened, customized, and intelligent production mode, as part of an intelligent manufacturing network for the future.

In 2021, Guizhou Tyre, China Unicom, and Huawei will continue their cooperation in 5G innovative application in terms of the industrial vision inspection system in collaboration with AGVs and RFIDs, and the wireless equipment operation and maintenance platform, etc. They will keep deepening product standardization and modularization, and make the project a stable, reliable product that can be quickly promoted in large scale.

In the second half of 2021, the company plans to launch the pilot application of 5G private network in the intelligent campus based on the needs of the factory, involving intelligent personnel management, energy consumption management, and safety and fire-fighting integration. This plan aims to combine intelligent campus management with the 5G-connected flexible factory and explore data fusion application to lay the foundation for building an integrated, fully-connected modern factory with centralized management.

In 2021, the company will implement more pilot application based on the MEP platform to replace the large number of isolated IPC, PLC, and SCM systems on site, thus achieving flexible expansion of edge computing power.

5G Intelligent Factory of Airbus Tianjin

With the popularization of 5G technology, the manufacturing industry will usher in a transformative development stage where the integration of communications and manufacturing industries will increase dramatically. Airbus China Innovation Centre is willing to be a leader and practitioner in integrating 5G and aviation manufacturing to jointly develop a new pattern of 5G+intelligent manufacturing and embrace high-speed and high-quality development of intelligent manufacturing.

Sun Lu
Head of Airbus China Innovation Centre

SOLUTION PARTNERS AIRBUS | 中国移动 China Mobile

OVERVIEW

Airbus (Tianjin) Final Assembly Company, also known as Airbus Tianjin Final Assembly Line, is located at the east of Tianjin Binhai International Airport in the Tianjin Airport Economic Area. It is a joint venture among Airbus, Tianjin Free Trade Zone, and Aviation Industry Corporation of China, Ltd., and is dedicated to high-grade, precision and advanced intelligent manufacturing.

The project was implemented in Airbus Tianjin, focusing on four major scenarios of material management, personnel management, production management, and delivery management in the Airbus production line. By fully integrating advanced technologies such as mobile 5G private network and AI video, the project created 5G-based solutions including "5G+ object persistence management", "5G+ perimeter intrusion management", "5G-based intelligent tool cabinet", and "5G+ AR remote delivery". The project was officially launched in July 2019, with business requirements communicated and clarified. In August 2019, business demonstration of the 5G intelligent factory was completed. In September to November 2019, a 5G private network solution meeting Airbus' requirements was developed. In January 2020, the cloud deployment of 5G applications such as face recognition, staff wearing helmets and FOD bags, object persistence detection, and perimeter intrusion warning was launched and finished the demonstration for France Orange Group In March 2020, the 5G firewall from China mobile side was launched after evaluated by Airbus. In May to July 2020, the end-to-end debugging based on the SA+MEC network was finished, and various 5G scenarios were verified in the production area, with solution operations evaluated and test reports generated. In September 2020, the business contract for the 5G private network was signed. In September 2020, we won the second prize in the national finals of The Third Blooming Cup 5g application competition.

CHALLENGES

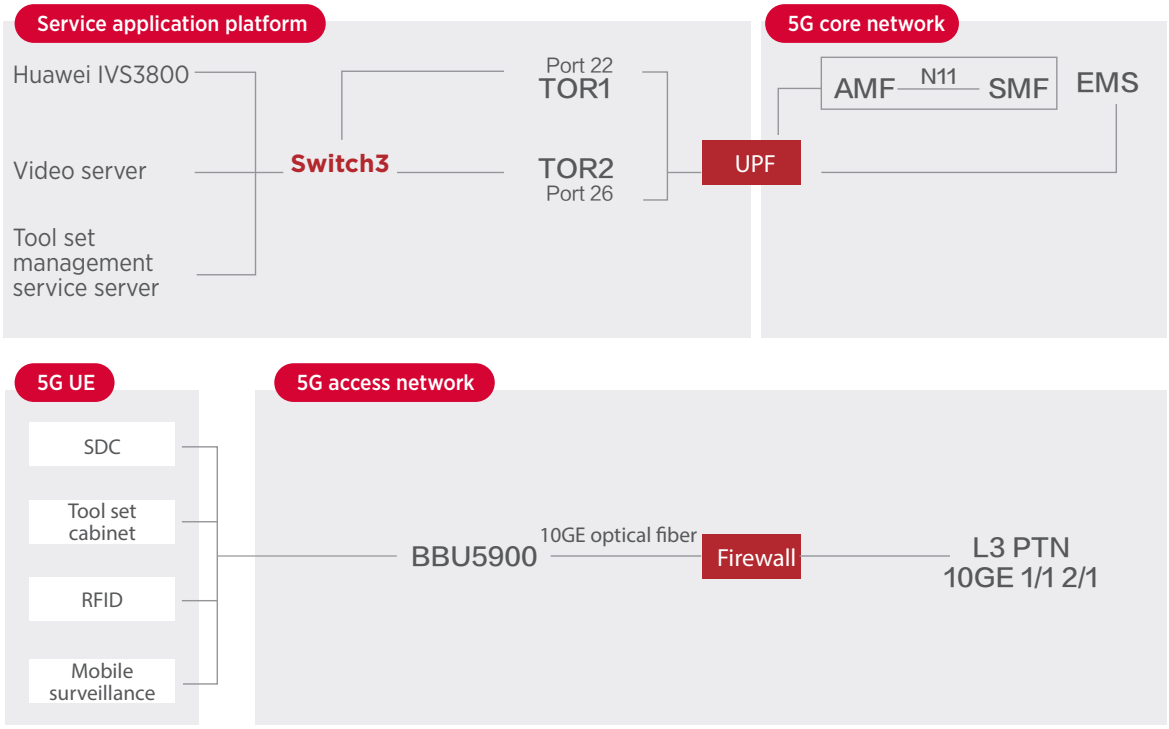
The integration of the high-grade, precision and advanced manufacturing industry represented by Airbus and the next-generation information and communication technology is gaining pace, driving the rapid development of a new manufacturing system led by software-defined, data-driven, platform support, value-added service, and intelligence. As such integration becomes reality, it is imperative for the manufacturing industry to transform toward intelligent, flexible, service-oriented, and high-end operations, which also raises increasing demands for wireless networks that feature high performance and flexible networking.

Traditional industrial networks are subject to unstable latency, data silos, and security risks among other problems. The inconsistent industrial fieldbus protocol standards make it hard for equipment from different manufacturers to be connected, and thus equipment statuses cannot be monitored effectively. To supply this gap, traditional manufacturing enterprises have to invest lots of manpower and resources in planning and scheduling, material distribution, production coordination, quality control, and equipment testing among other processes. In addition, if enterprises adopt the best-effort transmission mechanism of traditional IP networks, unstable latency and packet loss may occur, and data may become unavailable in latency-sensitive scenarios. Meanwhile, network security problems are also frequent. As

IPCs usually don't apply patches, they will be vulnerable to intrusions and attacks once exposed to an external network, causing considerable losses to enterprise users.

The 5G technology, characterized by high speed, low latency, and large capacity, is perfect to be used to upgrade networks for new industrial transformation and upgrading, especially the manufacturing industry. Specifically, the biggest highlight of 5G technology lies in its role of driving man-machine-thing interconnection, which can secure a ultra-low latency at a few milliseconds and nearly 100% reliability for data communication. This can guarantee the real-time control and early warning of the industrial internet. The unprecedented transmission speed and coverage of 5G will promote the intelligent collaboration of men, machines and things, and trigger major changes in the manufacturing industry.

SOLUTION AND VALUE



Networking Architecture of Airbus 5G Smart Factory

The application terminals of the 5G Smart Factory of Airbus Tianjin include 5G cameras, 5G-based smart tool cabinets and mobile monitoring equipment. They are deployed in related business areas to collect data, and the data is then transmitted over the large-bandwidth 5G network and processed locally in the closed loop of MEC, to ensure that the data stays on the Airbus campus. This achieves real-time, safe, and reliable transmission of video data in Airbus's intranet. Specifically, the 5G network bandwidth requirements of single-station 5G application scenarios are as follows:

Application Category	Typical Application Scenarios	Quantity	Uplink Bandwidth per channel	Overall Uplink Bandwidth Requirement	Network Latency	Concurrency
Intelligent video in production (per assembly line station)	Intelligent video for station boarders	16-channel	4Mbps/channel	Total number of concurrent video channels: 16+25*20%+2+4=27 I-frame concurrent channels meeting requirement of 99.99% scenarios: 10 Overall uplink bandwidth requirement: (27-10)*4Mbps+10*12Mb Ps=192Mbps	<50ms	100%
	5G+ video intelligent management for tool cabinet	25-channel	4Mbps/channel		<50ms	20%
	5G-enabled mobile HD video surveillance	2-channel	4Mbps/channel		<50ms	100%
	5G+ video intelligent surveillance access control	4-channel	4Mbps/channel		<50ms	100%

The above table shows that the overall uplink bandwidth required by a single station is 192Mbps, which is far from being satisfied by a traditional 4G network. Meanwhile, the Airbus Tianjin factory has a complex environment and centralized equipment arrangement, leading to difficult wiring. Therefore, the wireless 5G network option has become the best choice. After on-site testing, the uplink and downlink speeds of the Airbus 5G private network can support up to 20 concurrent cameras, enough to ensure normal operation in production scenarios.

Technological innovation

1 A highly integrated video platform

The front-end devices of software-defined cameras are used as video equipment, so as to deploy some video algorithms to the front-end cameras to save network bandwidth. The back-end IVS video analysis platform can integrate HoloSens Store, so that customers can download and automatically load video algorithms as needed to quickly and easily apply applications to the production system.

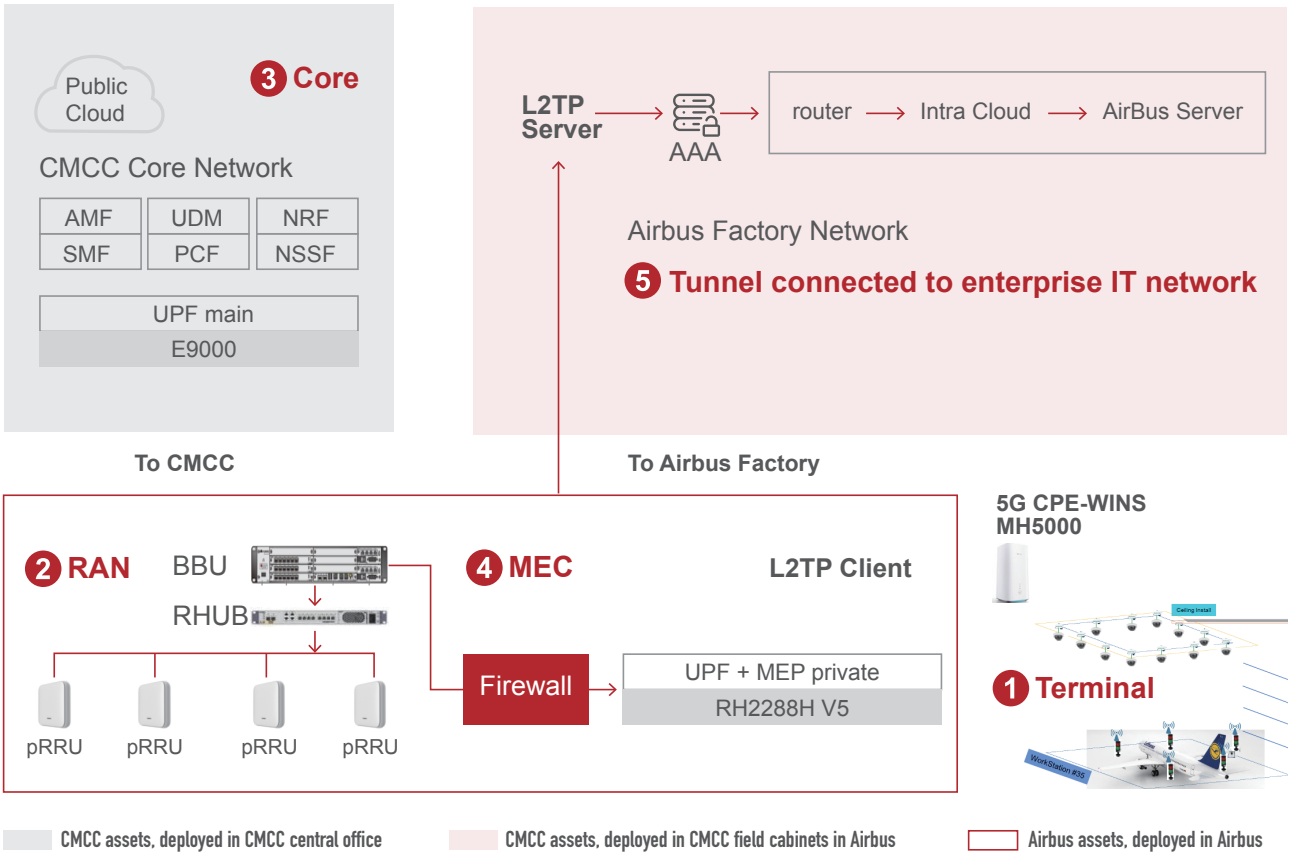
2 5G smart terminal - 5G camera

5G cameras have four innovations. First, the video data packet mode of traditional cameras is easy to cause video freeze, and 5G cameras have solved this problem. Second, 5G cameras innovatively adopt an I-frame collision avoidance mechanism. Unlike multi-channel traditional cameras, 5G cameras can avoid video freeze caused by sudden I-frame collisions. Third, 5G cameras well match the 5G air interface transmission characterestics. Fourth, 5G cameras can support the transmission of 4K high-definition videos and meet the high-resolution image requirement for AI analysis.

3 Mobile 5G private network meeting the actual needs of Airbus

The overall architecture of the mobile 5G private network solution is shown in the following figure:

The solution is primarily composed of 5G indoor distribution base stations, 5G SA core network, 5G MEC, transmission and network



Overall Architecture of the Mobile 5G Private Network Solution

element equipment of other related systems, which can guarantee the real-time and reliable transmission of Airbus's 5G application data.

According to the feedback of Airbus's field business supervisors and staff on the implementation of this project, the solution will bring huge social and commercial values in the following aspects:

(1) Production efficiency enhancement: Equipment experts can leverage 5G+AR video interaction and other applications for remote collaboration and operation, lowering the frequency of personal visits to the site for problem identification and reducing the commuting time, while enhancing the operation efficiency.

(2) Production quality improvement: 5G+AI+video detection can identify surface defects of key processes through online monitoring and carry out automatic analysis. This can not only facilitate manual inspection, but also automatically report or review the 5S status on site to make workplace management more efficient.

(3) Production safety improvement: 5G+ perimeter video detection can establish and improve the system's active warning capability. Using HD cameras to monitor dangerous environments instead of sending staff on site can markedly decrease personal injuries.

(4) Delivery efficiency improvement: The process from manufacturing to delivery of an aircraft requires on-site communication involving 40 to 50 persons/times on average. Supposing that 60 aircraft are delivered every year, and on-site communication involving 2,400-3,000 persons/times will be needed every year. If one fifth of such efforts are replaced by the remote approach, the travel expenses of 480-600 persons/times can be saved every year. In a traditional delivery solution, travel expenses and waiting time are important factors leading to the high interaction cost. The specific cost estimates are shown as follows:

Item	Intra-city	Intra-province	Domestic	International
Transportation	RMB 50-100/one channel	RMB 200-400/one channel	RMB 500-2,000/one channel	> RMB 2000/one channel
Accommodation	/	RMB 300-600/day		> RMB 600/day
Waiting time	0.5-1 hour	4 hours	6-12 hours	12-24 hours

Meanwhile, since remote inspection requires almost no waiting time and can be initiated anytime, it greatly lowers time cost and thereby boosts delivery efficiency.

The 5G Smart Factory of Airbus Tianjin has received wide attention from relevant departments of the Airbus Group since its inception. The ICT department of Airbus Group inspected the Airbus Tianjin site to learn the progress and provided support to its implementation. The achievement of the project was also highly recognized. At the World Economic Forum Annual Meeting 2020, the Airbus Group CTO also mentioned the 5G project achievements made by Tianjin Airbus. Senior officials of the French Orange Group also visited Tianjin Airbus in February 2020, and expressed their hope to replicate the applications of this project to relevant French companies.

REFLECTION

The 5G Smart Factory of Airbus Tianjin project is based on the 5G+MEC solution. In view of the high-end manufacturing scenarios of the Airbus Tianjin Final Assembly Line as well as its specific requirements and challenges, the AI smart video and other related technology have been integrated to digitize and innovate personnel management, material management, production management and delivery management of the factory. These efforts have helped the Airbus Tianjin factory with its upgrading and transformation toward 5G-based digital intelligent operations.

The on-site 5G private network deployment and 5G application scenario verification have proven the huge value of the 5G+AI+video solution in smart manufacturing scenarios. Meanwhile, the four 5G application scenarios of the Airbus project, namely personnel management, material management, production management and delivery management, are highly generic and can be promoted in scale, making the solution worth further investment. The improved 5G+AI+video solution can promote the maturation of related industrial chains and output of standardized baseline solutions, which can lay a solid foundation for fast promotion and implementation of 5G smart video solutions in the manufacturing industry.

During the implementation of the Airbus project, higher requirements and challenges are proposed although the solution is verified to be mature and feasible. For example, the overall recognition of AI algorithms needs to be more precise, and the software and hardware solutions for large-scale, complex networking architectures are difficult to be deployed with technical or financial restrictions. For these reasons, the cost-effectiveness of the overall 5G toB solution should be further optimized, so as to help enterprises realize 5G+ intelligent video upgrading at a lower cost, through easier deployment, and with high-quality operation and maintenance. Next, the project team will use the Airbus project as an example project for demonstration and promotion.

5G BRT Connected Vehicle-Infrastructure Cooperative System

5G has arrived in the beautiful city of Xiamen. Congratulations on Xiamen's 5G BRT Connected Vehicle-Infrastructure Cooperative System project passing the acceptance test, which made it the first successful commercial implementation in China of its kind. In the future, the commercial model can be replicated for deployment in other regions, and provide rich services for commercial vehicles, special vehicles, and even private vehicles.

Chen Shanzhi
Vice President and Head of Specialist Committee of China Information Communication Technologies Group Corporation, and Director of State Key Laboratory of Wireless Mobile Communications

SOLUTION PARTNERS

厦门公交集团 XIAMEN PUBLIC TRANSPORT GROUP | China unicom中国联通 | 大唐移动 DTmobile | 金龙客车 KING LONG

OVERVIEW

In 2018, led by Xiamen's traffic management departments, Datang Mobile Communications Equipment Co., Ltd., a subsidiary of China Information Communication Technologies Group Corporation, signed a strategic cooperation agreement on 5G intelligent connected system with Xiamen Transportation Bureau and Xiamen Public Transport Group. The parties aimed to jointly build a China-leading 5G intelligent connected vehicle-infrastructure cooperative system based on the well-developed BRT road resources in Xiamen. In September of the same year, Datang, in collaboration with Xiamen Public Transport Group and China Unicom, officially launched the Xiamen 5G BRT Connected Vehicle-Infrastructure Cooperative System project, China's first city-level 5G intelligent connected application.

As of August 2020, the equipment and facilities along the 60 kilometers of BRT roads and at five traffic light intersections and on 50 BRT buses have been upgraded. In August 2020, Xiamen Public Transport Group sent an expert group to complete the acceptance review of the project through field vehicle inspection and query & reply meeting. The smooth acceptance also marked the project's success as the first commercial application of connected vehicle-infrastructure cooperative system in China.

BRT Intelligent Connected Buses

Intelligent Intersection Equipment

SOLUTION

The Xiamen 5G BRT Connected Vehicle-Infrastructure Cooperative System enables Vehicle-to-Infrastructure, Vehicle-to-Vehicle, and Vehicle-to-Cloud communications, and can provide BRT bus drivers with more driving assistance by means of roadside sensing and cooperative awareness. The system not only facilitates active safety measures to reduce the frequency of rear-end collisions and collisions at intersections involving BRT buses, but also increases the operational efficiency of the entire BRT system and energy efficiency through the adoption of big data, energy-saving optimization algorithms, high-precision maps and intelligent route planning on the 5G MEC platform. In addition, the integration of 5G and high-precision positioning technology also delivers customized applications such as safe and precise parking of BRT buses.

By integrating advanced networking technologies such as 5G, C-V2X, and MEC (Multi-access Edge Computing) with on-board vehicle intelligent driving technology, the solution builds an IoV system architecture that consolidates information from intra-vehicle, inter-vehicle, and vehicle-cloud networks based on the 5G converged gateway on BRT buses.

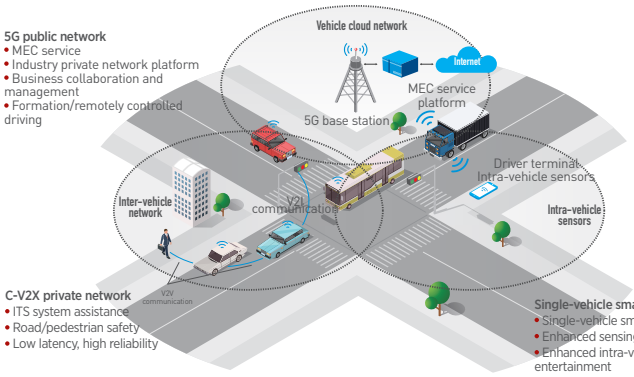
Intra-vehicle network: The integration of the internal bus network with onboard sensors through the 5G converged gateway can provide more comprehensive driving assistance information to the driver and the vehicle's decision control system. Meanwhile, the network also ensures communication security between the vehicle and external devices through the security encryption chip built into the gateway.

Inter-vehicle network: The network allows vehicles to interact with other vehicles and roadside infrastructure (such as traffic lights) using

V2V and V2I communications through the 5G onboard converged gateway.

Vehicle-cloud network: The network provides route planning, energy-saving strategies, high-precision regional maps and other applications to buses using the central cloud and roadside MEC edge cloud platforms that interact through the Uu port communication module built into the 5G onboard converged gateway.

To implement the converged network, the project needed to upgrade equipment and facilities on BRT buses and at public intersections. For public intersections in particular, it was difficult to deploy fixed connections due to challenges of rights of way and construction processes. Therefore, 5G was used to provide connectivity between the sensors at the intersections and the MEC platform that meets both their bandwidth and latency requirements. For the bandwidth requirements, a typical simultaneous video surveillance device (e.g. 4-channel 1080p feeds at 30fps) at an intersection will require an uplink bandwidth of at least 32 Mbps; and for latency, 3GPP, ETSI, and other standardization organizations require no greater than 100ms of end-to-end latency for active security applications. However, the inherent latency from video collection and encoding is already around 60ms, forcing transmission delay to be at the most 30ms. The table below shows the results of a field test on 4G and 5G networks in Xiamen.



Converged Network for 5G Intelligent Connected System Architecture

	Uplink Speed	Downlink Speed	End-to-End Latency
4G Network (average values)	10Mbps	90Mbps	58ms
5G Network (average values)	145.29Mbps	566.4Mbps	23ms

COMMERCIAL APPLICATIONS

Leveraging the advantages of 5G and C-V2X technology, the project implements four main commercial applications: real-time vehicle-infrastructure collaboration, intelligent speed strategy, safe and precise parking, and non-LOS anti-collision.

01 Real-time Vehicle-Infrastructure Collaboration

The vehicle-infrastructure collaboration technology makes intersection devices intelligent by using laser radars, HD cameras, and MEC edge servers and connecting them to the traffic light system. This architecture can deliver two services.

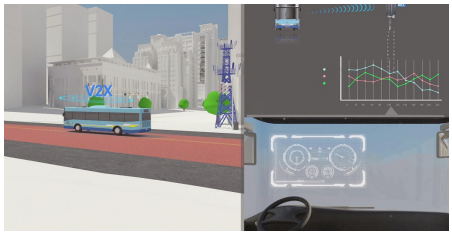
First, 360° blind spot detection at intersections. The laser radars, HD cameras and other devices can monitor intersections holographically around the clock to obtain details of pedestrians, motor vehicles, non-motor vehicles and other traffic participants at intersections for behavior prediction. This can effectively reduce traffic accidents involving BRT buses at intersections.

Real-time Vehicle-Infrastructure Collaboration

Second, smoother green light traffic flow. After getting connected to the intersection traffic light system, roadside equipment can obtain data on the status and duration of traffic lights in real time and send the data to the buses. Meanwhile, the system can also control the traffic lights at the intersection ahead of the BRT bus to allow the bus to pass first, improving public transportation efficiency. According to analysis, these techniques could reduce the average bus travel time by more than 15%.

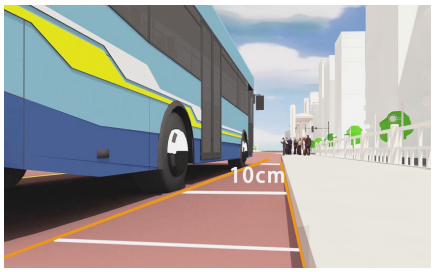
02 Intelligent Speed Strategy

The intelligent devices such as roadside sensors and onboard sensors can monitor road traffic in real time and upload such data to MEC servers over the 5G network, and the 5G MEC deployed with the intelligent speed strategy derives optimal driving speeds based on the historical vehicle traffic data and driver behavioral records and send them to vehicles. This allows vehicles to adjust their speeds more smoothly and avoid sudden acceleration/deceleration or stops. Intelligent speed strategy would also cut down on emissions and reduce fuel consumption by about 10% of every 100 km.



Intelligent Speed Strategy

03 Safe and Precise Parking



Safe and Precise Parking

Passengers could easily fall into the platform gaps because the platforms are quite high off the ground and some distance away from the buses. With high-precision maps, converged sensing algorithms, route planning and other strategies deployed, the MEC platform can send a large amount of data to vehicles in real time. Vehicles will then be able to better adjust their entry path when approaching stations to ensure that the gap between the bus and platform is only a few centimeters. To ensure that the MEC platform can obtain precise positioning data, the project also deployed a high-precision positioning base station along the BRT route. According to analysis, the distance between the bus and the platform can be less than 10cm to ensure the safety of onboarding and offboarding passengers.

04 Non-LOS Anti-collision

Non-LOS Anti-collision

Two BRT buses travelling in the same direction on the same lane can communicate in real time to share each other's speed, location, course angle and other information. When the distance between the two buses gets smaller than the defined safety distance after the bus ahead slows down, brakes or stops, or the bus behind speeds up, which makes a collision possible, the bus behind will gradually slow down or stop in advance based on the TTC value. The display units equipped in the buses will also give voice alerts to ensure travelling safety. The anti-collision mechanism based on inter-vehicle communication is not impeded by poor visibility or weather conditions. Besides, compared with the single-vehicle sensor mechanism, this solution can greatly increase the vehicle's range of perception up to 450 meters while reducing the anti-collision cost per vehicle.

REFLECTION

After the 60 kilometers of roads and 50 BRT buses were all upgraded with 5G equipment in 2020, the project has moved from the initial test and verification stage to the overall operation stage. Since there was no precedent large-scale intelligent transport project in the country for reference, this project has encountered many challenges after starting all-round operation.

First, in terms of vehicle operations, despite the convenience, drivers need to adjust their driving behavior and habits to well manipulate the intelligent connected vehicle. In this regard, related training courses have been developed and more than 150 BRT drivers have received this training. This has not only improved drivers' overall expertise, but also accumulated rich experience for establishing vehicle driver certification standards.

Second, in terms of overall route operations, the scaled operations empowered by 5G, C-V2X, and high-precision positioning technologies have enabled dispatchers to get vehicle status, traffic conditions and passenger traffic anytime, so that they can quickly adjust dispatching plans, publish vehicle operation information and interact with a vehicle in real time. This is virtually a revolutionary change to the daily work of dispatchers. Deepened cooperation with the transport industry has been carried out to optimize the big data cloud platform on public transport so as to realize automated and intelligent dispatching of bus routes, and train more dispatchers who are able to handle the new type of dispatching work.

The system can be implemented and deployed in phases, and support forward compatibility and future evolution, and is already stable for wider commercial deployment. It has been demonstrated in various cities throughout China and in commercial operations in Xiamen and Hangzhou. It can be expanded into other public transport systems, such as taxis, ride-hailing platforms, freight transport, and eventually private vehicles, making it a vital support system for intelligent transport. In summary, the Xiamen 5G BRT Connected Vehicle-Infrastructure Cooperative System project, as a successful attempt and demonstration to pioneer vehicle-infrastructure collaboration and its business mode, has positive significance for promoting technological, industrial, and business mode innovation. It will play an even bigger role in building an innovative ecosystem of the intelligent transport industry and cultivating vehicle-infrastructure cooperative clusters.

Distributed General-purpose Machine Vision Platform Based on 5G MEC

MEC is one of the core features of the 5G new infrastructure, and the basis for one-hop access to cloud and a deterministic network with low latency and high bandwidth. Based on MEC, services with high-density computing, high traffic, and low latency requirements can be deployed on nearby nodes to meet customers' demands for security, speed, and reliability. China Telecom's independently developed MEC platform, based on China Telecom's great wealth of network and edge computing resources, provides customers with an MEC edge computing environment that is accessible from single nodes across the nation and supports terminal-edge-cloud collaboration. The 5G MEC-based distributed general-purpose machine vision platform jointly created by China Telecom and ZTE has greatly boosted the efficiency and reliability of traditional operating processes. In the future, China Telecom will join hands with more industry partners to inject new vitality to the MEC application ecosystem and empower more industries.

He Zhiqiang
General Manager of the Science and Technology Innovation Department of China Telecom Group and Dean of China Telecom Research Institute

SOLUTION PARTNERS 中国电信 CHINA TELECOM | ZTE中兴

OVERVIEW

Pooling efforts from China Telecom and ZTE Corporation, this project features a deep integration of 5G MEC and machine vision advantages. Leveraging China Telecom's diverse network and computing resources and professional operation and maintenance capabilities, coupled with machine vision algorithms, the project provides factories with efficient and stable cloud-based industrial machine vision solutions to boost industry upgrading. The project deploys the factory's machine vision system on the MEC platform independently developed by China Telecom. Based on 5G wireless connections and MEC capabilities, the solution simplifies the detection and identification of on-site IPC solutions and field equipment, enhances software/hardware performance, speeds up data transmission and vision algorithm optimization, and guarantees the security of campus data.

The distributed general-purpose machine vision system based on 5G MEC integrates industry-leading AI vision detection algorithms and supports detection tasks by using multiple algorithms in industrial production scenarios. Meanwhile, it enables the management of people (face recognition, personnel status analysis, safety helmet detection, etc.), machine (equipment control, material inlet/outlet clogging analysis, conveyor deviation monitoring, etc.), data (material information OCR collection, material appearance and quality inspection, etc.), environment (environmental inspection, video perimeter analysis, etc.), process (quenching visual analysis, bolt pre-tightening sequence guidelines, etc.), and product quality (packaging inspection, measurement, positioning, etc.) to meet the daily production and operation needs of most factories.

CHALLENGES

As computing, storage, and sensor technologies evolve on, machine vision has quickly grown into an emerging practical science and technology. It can replace human eyes to identify, track, measure, and detect targets, and offers navigation services for special populations in a highly effective manner. The current global machine vision market has exceeded tens of billions of US dollars in output value. In China, thanks to policy, technology, and market demand among other factors, the size of the market is also growing by more than 20% every year.

Machine vision can help factories improve production and inspection efficiency, and strengthen the management of factory personnel, materials, environment, and safety. However, traditional machine vision solutions have obvious shortcomings in industrial vision inspection. For example, based on wired-network-connected station deployment, IPCs are also required at each station in addition to the camera/light source, which is difficult. The stations function independently, making it hard to aggregate images and data. The stations have limited computing power and the data cannot be shared over the cloud. Solutions are highly customized, and algorithms are difficult to get

improved. 5G MEC can well solve the above problems.

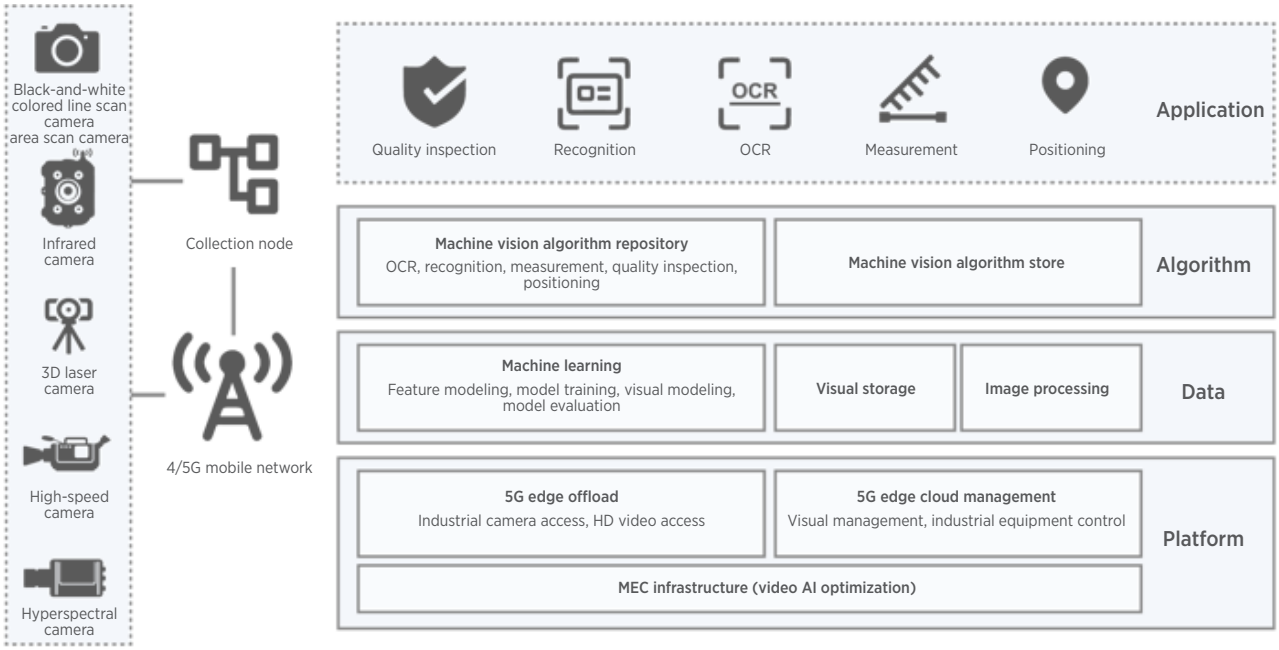
First, replacing the wired network with 5G wireless deployment can simplify field equipment and IPC solutions, so that machine vision has a higher degree of flexibility in deployment, and technical transformation can be quickly completed for the existing lines without adjusting the network wiring scheme. Second, the 5G MEC network features large bandwidth, low latency, and high computing power, which can fully meet the requirements of machine vision inspection scenarios in these respects. Based on 5G and edge cloud technologies, the project deploys machine vision detection and recognition tasks on the MEC platform to ensure more powerful computing and storage capabilities. Meanwhile, the solution also accelerates algorithm iteration and optimization, which is conducive to improving industrial production/testing efficiency and promoting intelligent industrial production.

SOLUTION AND VALUE

01 Technical Solution

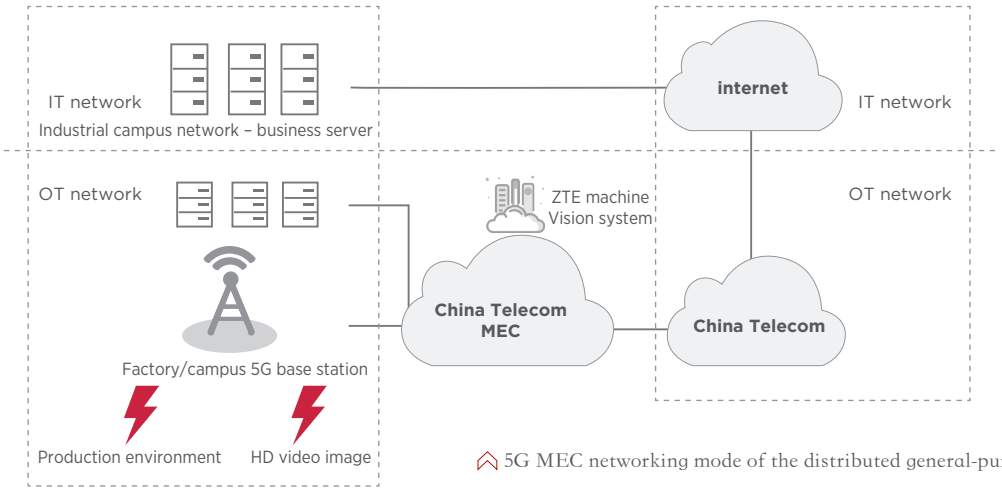
The project is based on a 5G quasi-private network to create a cloud-based industrial machine vision solution. It supports industrial video collection, storage, and analysis to provide data services to companies, developers, and individuals, and supports visual AI algorithm training and computing resource scheduling to provide training services to algorithm developers.

In terms of product architecture, the distributed machine vision system includes three modules: digital image collection, digital image analysis and processing, and control execution. The digital image collection module transmits digital images back to the cloud through the 5G network. In some environments, it can also transmit digital images through multi-card binding and bandwidth aggregation. The digital image analysis and processing module is deployed on the edge of the MEC platform and is responsible for analyzing video images by using image processing algorithms and AI algorithms. The control execution module is also deployed on the edge of the MEC platform and is responsible for making decision analysis and control based on the results of the digital image analysis and processing module. The module can improve the production process and strengthen campus management.



Design scheme of the distributed general-purpose machine vision platform

In terms of the project implementation plan, we deployed MEP edge nodes to achieve full coverage of 5G signals across the campus. The MEC edge cloud provides IaaS, algorithm and analysis PaaS capabilities, as well as practical SaaS applications such as quality inspection, identification, and OCR, which can be loaded on demand. HD industrial cameras and other 5G terminals collect HD video streams in various areas of the campus and transmit the data over the 5G network to the MEC edge cloud with one hop in a proprietary way. The machine vision algorithms loaded on the edge cloud analyze the video streams from various dimensions to get valid visual information and output analysis results to complete tasks such as quality inspection, equipment control, personnel management, and safety prevention and control.



5G MEC networking mode of the distributed general-purpose machine vision platform

02 PROJECT APPLICATION

The project introduces a large number of general and practical algorithms from the aggregation algorithm store, which can quickly generate machine vision solutions matching the scenario to meet general clustering needs. Currently, the project has been implemented in factories in Hunan, Jiangsu, and other places, and is being promoted to other companies.

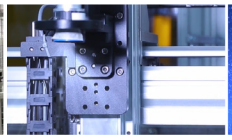
AAU (Active Antenna Unit) Visual Inspection Solution of Nanjing Binjiang Factory

ZTE cooperated with China Telecom Nanjing Branch to build a safe and reliable 5G smart workshop for Nanjing Binjiang Factory through 5G network slicing and MEC technologies. The solution empowers intelligent manufacturing with 5G + machine vision to inspect the front-end screw and dispensing quality of AAU products. It can inspect 204 objects at the same time with an accuracy rate of 97%, greatly improving the assembly efficiency of the workshop.

Machine Vision Quality Inspection Solution of ZTE Changsha Factory

ZTE Changsha Smart Factory cooperated with China Telecom Hunan Branch to apply 5G + MEC + HD industrial cameras in a comprehensive manner for appearance inspection of gaskets, upper covers, packaging boxes, and other products. After the 5G MEC machine vision system was commissioned, the single detection time reached about 0.5 seconds, and the detection accuracy rate reached 95%, which makes the solution an effective alternative to manual visual inspection, solving the low efficiency, missed or false detection, and other problems while reducing the industrial production/detection costs.

Robotic arm guide in Binjiang Factory



Connecting rod installation inspection in Binjiang Factory

Screw inspection in Changsha Factory

REFLECTION

Currently, the project has achieved the desired goal with our great efforts, as evidenced by the provision of 5G MEC + machine vision solutions to multiple factories, with favorable returns recorded. Main contributors to the success of the project include the following:

1. Flexible use of the MEC technology. MEP edge nodes are deployed in the campus to effectively reduce the requirements for network transmission bandwidth and network load, so that data can stay within the campus while users can enjoy high-speed, low-latency, and reliable cloud network services. This helps promote the intelligent upgrading of the industrial campus.
2. The project has an open MEC algorithm store that integrates a wealth of high-precision AI detection algorithms to meet the needs of general-purpose business scenarios. Users can purchase and load the algorithms on demand, make purchases at one go, achieve national coverage, complete deployment with one click, and deliver services in a uniform manner.
3. Flexible manufacturing. The project enables line transformation and upgrading through machine vision, so that products of multiple specifications can be manufactured on the same line and multiple production lines can share some of the lines (such as packaging lines). This can significantly reduce the cost, while improving the production efficiency.
4. Well-fledged business model. The project offers a 5G MEC + machine vision technical solution to business customers to make gains. The solution is well-developed with all-round technical support, and can be promoted on a large scale.

The project will continue to speed up MEC edge node construction to achieve nation-wide coverage, and explore machine vision applications in the industrial Internet to meet the needs of more industrial production scenarios.

5G+MEC Smart Healthcare of Shenzhen Futian Medical Consortium

The 5G era is an opportunity for the medical industry, and a key for operators and medical information companies to probe into the medical industry.

Chen Hao
Director of Information Department under the Eighth Affiliated Hospital of Sun Yat-sen University

SOLUTION PARTNERS 深圳市福田区卫生健康局 | 中山大學 附属第八医院 THE EIGHTH AFFILIATED HOSPITAL, SUN YAT-SEN UNIVERSITY | 中国移动 China Mobile | HUAWEI

OVERVIEW

Futian Medical Consortium, China Mobile, Huawei and other organizations have jointly advanced 5G + smart healthcare projects in Shenzhen since 2019. By deploying the private medical network of the medical consortium, the project took the lead to build 5G remote emergency, 5G remote consultation, 5G mobile diagnosis and treatment, 5G community first aid guidance, and 5G smart wards applications on the basis of efficient and safe information sharing among all medical institutions in the district (seven hospitals, and 83 community health centers), and contributed to remote, mobile, and informatized upgrading and transformation of Futian Medical Consortium services. During the COVID-19 pandemic, the project helped implement a hierarchical medical system through bedside consultations, remote consultations, and community first aid services over the 5G + MEC private medical network to help prevent and control the pandemic.

According to the actual hospital scenarios, three major innovations of network, terminal and industry have been achieved from technology to business, including the establishment of a private 5G healthcare network, 5G medical terminal R&D, and all-scenario application of 5G smart healthcare solutions in, between, and out of hospitals. Meanwhile, the project achieved five world's firsts:

5 world's firsts

1. Among the first batch to formulate 5G network construction standards
2. The first transformation of 5G medical carts
3. The first pre-hospital emergency care based on a private 5G network
4. The first 5G smart emergency cart
5. The first regional 5G SA private medical network

CHALLENGES

The informatization of the medical industry faces the following challenges:

Higher degree of communication robustness required by new services

In particular, medical video and imaging data puts forward new requirements on network bandwidth, transmission quality, transmission rate, and reliability. Meanwhile, 3GPP/ITU and other international standards and industry organizations are studying smart healthcare scenarios and applications. More than 20 new services are expected to enter the new medical ecosystem, and new applications derived from new technologies will place higher requirements on communication networks.

Risk of data leakage

The medical information system collects a large amount of patients' health information, such as electronic medical records and medical images. It becomes a challenge to protect patients' personal privacy and medical data from leakage and tampering.

Difficulties in data freezing and sharing

Due to the inconsistent information system standards of various medical institutions, clinical information is not shared across departments and hospitals. Hospitals have a low level of data integration, with little data being shared across departments and hosptitals, resulting in a low utilization rate of medical data resources.

SOLUTION AND VALUE

The 5G smart healthcare project of Futian Medical Consortium is based on 5G MEC and slicing technology and deploys a regional private 5G healthcare network to cover in-hospital, inter-hospital, and out-of-hospital scenarios. The project meets the needs for limiting medical data access within the hospital, high bandwidth, low latency, flexible access, etc.

01 Structure

The project focuses on the establishment of a private 5G healthcare network, 5G medical terminal R&D, full-scenario 5G innovative applications and other aspects. With a fast and stable private 5G network, the project achieves multi-platform collaboration to create all-round 5G applications including mobile diagnosis and treatment, hierarchical diagnosis and treatment, and smart wards.

02 Network: Regional private 5G healthcare network to cover medical services and public health

Regional private 5G healthcare network: Covering seven hospitals of Futian Medical Consortium and 83 community health centers, the solution designs an innovative regional 5G healthcare network with a MEC platform.

Public network for private use: In the Futian Medical Consortium project, the 5G + MEC + slicing technology have been utilized to build a virtual private network based on the "5G public network for private use" architecture.

- Following the model of public network for private use, the project meets the communication needs of both medical applications and public users in hospitals.

- The solution features a low cost, high performance, wide coverage, and high security and reliability.

Low cost: The construction and maintenance costs of the private network are too expensive for some district hospitals and community health service centers. In the case of a 5G network, the operator is responsible for the construction, operation, and maintenance of 5G public network. Following the mode of public network for private use, the solution can help the medical industry quickly build a private network at a low cost.

High performance: The high bandwidth and low latency features of the 5G network can meet the real-time transmission needs of a large amount of medical devices, medical images, and high-definition videos, so as to relieve the transmission load and bandwidth pressure of the hospital intranet and the inter-hospital wired private healthcare network.

Wide coverage (wide scope of services): Operators' networks have inherent advantages in coverage and can provide services wherever the coverage reaches, meeting the wide coverage and mobility requirements of private networks. In the Eighth Affiliated Hospital of Sun Yat-sen University project, the private 5G healthcare network connects the inside and outside of the hospital to build a regional emergency system and a hierarchical medical system involving the hospital and community health centers, so as to speed up pre-hospital emergency care and extend the medical service scope.

Security and reliability: With the help of new technologies such as 5G slicing + MEC, the solution enables secure network isolation, so that users on a private network are isolated from public users. Operators' network equipment strictly complies with 3GPP's security standards. Medical terminals gain access to the network via dedicated cards, and all wireless devices that transmit data to the core network are required to be authenticated before access. Operators' MEC server rooms comply with Class 3 security standards, and the MEC servers are connected to the hospital's data center via a private line to provide end-to-end physical isolation and security for the private network.

MEC: It is the key enabling technology in the private 5G healthcare network solution. The MEC techonology enables medical data to be stored within the limited premises, ensuring real-time interactions for low-latency services.

SA independent networking & end-to-end slicing: China Mobile Shenzhen has built 15,000 5G base stations to achieve full coverage of 5G SA independent networks, making it possible to implement the end-to-end network slicing technology. 5G SA end-to-end slicing guarantees the stable bandwidth and latency of medical services during peak hours, creating a stable network environment for medical services.

03 Terminal: Integrated 5G communication module on the medical cart to address the lack of 5G medical terminals

Medical cart (mobile terminal) implanted with 5G module: 5G medical terminal is a key process in 5G application. In particular, the mobile medical terminal's 5G communication module needs to be highly integrated with the terminal device in design, and the industry terminals that have 5G module integrated usually require a longer time for development, verification, integration and certification. Currently, 5G modules highlight problems of a large size, high power consumption, and difficulties in adaptation. In view of the above challenges, the 5G project team of the Eighth Affiliated Hospital of Sun Yat-sen University made a series of innovative designs and

explorations, and pioneered the integration of 5G communication modules on the motherboard of the medical cart (mobile doctor carts, mobile nursing carts, bedside consultation carts, remote video rounds carts, and smart emergency cart) to address the lack of 5G medical terminals. The practice is easy to be replicated and boasts demonstration significance, setting a milestone in the industry.

5G mobile doctor cart

5G mobile nursing cart

5G bedside consultation cart/remote video rounds cart

5G smart emergency cart

The first phase of this application has completed the implantation of 5G modules on 36 medical carts in the first batch. The average download speed over a 5G network is 600 Mbps, with relatively smooth connections both inside and outside the room. The solution can load more than 500 CT image sequences within 10 to 20 seconds, without any delay in the browsing process.

5G router (Huawei CPE)

5G mobile phone

Huawei 5G Pad

5G PDA (end of 2020)

APPLICATION

Capitalizing the wide coverage of the 5G network and the convenience of seamless connections between the private 5G healthcare network and hospital intranet, the first phase of the Eighth Affiliated Hospital of Sun Yat-sen University project achieved multi-platform collaboration including the 5G home remote care platform, the smart regional emergency platform, the remote consultation platform, and the smart ward interaction platform.

1 Mobile medical care:
Through a 5G network, the solution uses 5G pads for daily ward rounds. Mobile doctor carts and mobile nursing carts can run various information systems on mobile medical workstations, making medical staff's mobile work more efficient and convenient.

2 Smart emergency cart:
When a patient needs emergency care in the community health service center, the regionally interconnected smart emergency cart system supports one-click activation of the smart emergency care. When expert guidance from the superior medical institution is required, users can request remote rescue guidance directly in the emergency interface. This feature makes joint emergency care available from both the hospital and community health centers, fully exerting the role of nearby community health centers on emergency care.

3 Pre-hospital emergency care:
With the private 5G healthcare network, the inside and outside of the hospital can be connected over the same network to offer in-hospital-like services in ambulances. The patient can be registered and a medical record can be set up in the ambulance, and the patient's vital signs, electrocardiogram, high-definition videos, and vehicle location information on the ambulance can be transmitted to the emergency command center of the hospital in real time, so that patient information can be ready before the patient arrives in the hostpital. Emergency doctors can then understand the patient's situation quickly and prepare for the emergency care in advance. The pre-hospital data is connected to the prescreening and triage system in the hospital. An emergency "green passage" can also be set up beforehand in the hospital, with the bed reserved, so that the in-hospital examinations and handovers can be minimized to save the treatment time.

4 Remote consultations:
Experts can access mobile consultations, ICU/special patient bedside consultations, and inter-hospital remote consultations through 5G mobile phones, 5G pads, and consultation carts anytime and anywhere. This approach breaks the restrictions in time and location and takes patients' actual difficulties into considerations, improving the diagnosis accuracy and guidance efficiency. On August 12, the solution supported the Beijing Xuanwu Hospital in a successful ICU bedside consultation. The audios and videos at both ends of the bedside consultation were clear and smooth without delay. Medical records, doctor's advices, images, examinations and other data were simultaneously displayed on the screen with zero waiting time.

5 Smart wards:
5G smart ward provides an integrated solution of auxiliary diagnosis and treatment, smart nursing and ward management based on the private 5G healthcare network connected to the hospital intranet. The 5G smart ward enables real-time data collection, transmission, and monitoring for patients' physical indicators, infusion monitoring and other data, helping hospitals improve management and work efficiency.

As of now, the Futian Medical Consortium 5G smart medical project has been in trial operation in the Eighth Affiliated Hospital of Sun Yat-sen University for three months. In the future, applications such as full 5G access for medical terminals, slice management systems for public network for private use, and precise positioning for the IoT will continue to be promoted and explored.

Private 5G Network with MEC and Network Slicing Promotes the Xinchang People's Hospital Medical Community

Private 5G network with MEC and network slicing is one of the important information infrastructure components for hospitals. New digital healthcare technologies have improved our doctors' ability to analyze patients' condition and plan surgeries. The holographic preoperative communication helps reduce risks for medical accident. The expert guidance through remote videos enhances the remote collaborative diagnosis and treatment, and is conducive to the efficient use of expert resources.

Yao Canzhen
Party Secretary of the People's Hospital of Xinchang

SOLUTION PARTNERS

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OVERVIEW

In 2019, Zhejiang province launched a initiative to build county-level medical and health service communities (referred to as the medical communities) to promote the sharing of high-quality resources to primary hospitals and improve the treatment capabilities of primary hospitals. The Medical Community takes the People's Hospital of Xinchang as the center and provides remote medical services for township health centers in the county. It hopes to use advanced information technologies in the medical industry and 5G smart medical applications to improve and implement a medical-community-based hierarchical medical system, to ultimately improve the ability of primary-level doctors in reading images and diagnosing and treating complex diseases.

After a research was conducted by China Unicom Group Zhejiang Company Limited and its partners at the People's Hospital of Xinchang, they focused on the expanded application of medical imaging and remote surgery teaching and guidance. In May 2020, the end-to-end 5G network slicing and MEC environment construction for the core network, the bearer network and the wireless network were completed. The first batch of pilot departments, including spine department, operating room, and Dashiju health center, could use innovative technologies such as 3D image reconstruction, MR-assisted surgery planning, and AR remote surgery guidance through 5G terminals. The technologies are applied to mobile ward rounds, doctor-patient communication, communication of diagnosis and treatment plans, and clinical teaching among other scenarios.

SOLUTION AND VALUE

Xinchang People's Hospital Medical Community's 5G network slicing is the first slicing test project of China Unicom Group Zhejiang Company Limited. It builds a 5G SA end-to-end network environment and verifies the SA network and slice configuration functions. Meanwhile, it builds an edge cloud computing environment for deploying business software, application terminals, and slice purchases. The system realizes "3D image reconstruction, MR-assisted surgery planning and AR remote surgery guidance" based on the "5G + MEC + slice" network.

01 High-performance MEC edge cloud

Medical imaging features a large data size, and traditional CPU-based 3D reconstruction algorithms cannot meet the requirements for real-time construction and rendering. To solve this issue, Xinchang MEC platform is equipped with GPU boards and uses GPU virtualization software to allocate GPU resources. This ultra-high-performance heterogeneous computing platform provides powerful 3D reconstruction, image rendering, and video processing capabilities while meeting the latency requirements of services. The MEC platform is also connected to the hospital's PACS system to receive real-time images such as CT and MRI images every day. The MEC server is equipped with SSD to ensure quick reading, writing, and storage of image data. Data can be stored for more than 10-15 days, the average hospitalization time of an inpatient. The doctor can retrieve the image data of the inpatient for medical diagnosis at any time.

02 Network deployment and slicing configuration

According to the pilot departments and health center locations of Xinchang People's Hospital Medical Community, the SA network coverage is archieved with the combination of macro base station and micro base satation. The virtual private network model of one network for dual purposes can address the communication needs of professional medical applications and public users. The core server room in Hangzhou has deployed the control plane, management plane, slice management unit and public user plane network units of the 5G core network, while the Xinchang local converged server room has deployed edge MEC/UPFs. On the core network, two slice IDs and DNNs are deployed respectively to distinguish between public services and slicing services. Different routing and QoS are configured accordingly. The wireless side uses a 5QI-based differentiated scheduling scheme for slicing, and the bearer network adopts hard slicing.

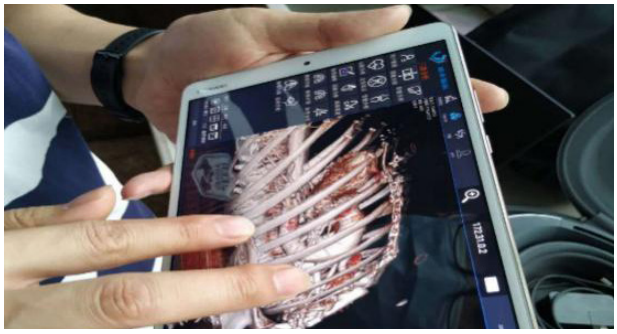
As shown in a test with the existing network, the average network latency is 7.8 ms, and the air interface bandwidth is larger than the bandwidth of the public slice. When the public slice is congested, general users may experience a freeze when using the video service on a mobile phone, while the medical services under the private slice can be used normally, without impacts from the high load of the public services. Relevant data is as follows:

Description of 3D impact reconstruction experience	Test bandwidth	Latency
Images can be zoomed/ rotated smoothly, with the latency imperceptible	20Mbps	10ms
Images can be zoomed/ rotated, with slight latency	10Mbps	110ms
Images can be zoomed/ rotated, with obvious latency	3Mbps	179ms

Public user 1 network usage	Public user 2 service experience	Public user 2 delay	Medical terminal service experience	Remote teaching terminal delay
100%	Video freeze/ long buffering	286ms	Smooth with no lag	28ms
50%	Smooth service	26ms	Smooth with no lag	27ms

APPLICATION

01 3D image reconstruction and 3D MR image display



3D image reconstruction

A medical 3D cloud imaging workstation based on 5G and MEC, which integrates efficient image processing, AI, mixed reality holographic visualization and cloud technology, supports image data acquisition, transmission, import and storage functions and various modules for different outpatient departments. 3D models are pushed to mobile terminals through 5G to enable the holographic display and omni-directional observation of 3D images. 3D printing is also supported.

When telemedicine is carried out between institutions in the medical community, the terminal only needs to access the local edge cloud to complete data reconstruction, requiring no additional local hardware or network configuration. The powerful intelligent retrieval, calling, reconstruction, segmentation, restoration and other functions of the

5G edge cloud medical workstation provide a new way of using image data, which helps unlock the value of image data.

The combination of 5G and MR (mixed reality) technologies converts 2D DICOM data into 3D images or animations, and presents them in real space to enable holographic visualization of image data, giving surgeons a "perspective view". This provides an innovative clinical, scientific research, and education and training solution for image data application in the surgery department which requires precision.

MR training

02 Remote surgery guidance and teaching

The private 5G medical network can ensure the real-time online interactions between the surgeon in the operating room and the experts on a remote terminal. With multi-channel HD videos transmitted in real time, and the AR technology which integrates the videos of the two parties in the same scene, the advice of the remote experts can be shared to the operation site, as if the experts were there guiding the operation hand-in-hand. This solution achieves real-time, visualized and precise remote operation consultation.

Meanwhile, the operation is broadcast live to the teaching and research room or the conference room. Doctors in these rooms can communicate with the doctors in the operating room in real time. Also, real-time remote observations can effectively improve the efficiency and quality of surgery teaching. Telemedicine services that run on a private 5G network can address the inter-hospital medical collaboration problem and offer guidance and training to help primary hospitals improve their services and increase the rate of visit and successful treatment.

Spine surgery demonstration and teaching room of the People's Hospital of Xinchang

REFLECTION

This project explored the application of the latest 5G + MEC + slicing technology in the medical industry. The 5G end-to-end network slices provide different QoS guarantees for different service types, ensuring the independence of public communications and the communications of medical staff/medical devices in the hospital. This translates to the high bandwidth, low latency, and real-time computing of SLA-based services in medical scenarios. The SLA modeling results of the 3D image reconstruction business have been incorporated into the "5G End-to-End Slicing SLA Industry Demand Research" issued by the China Academy of Information and Communications Technology (CAICT) to guide future medical applications.

With China Unicom as a key contributor, the project establishes a 5G smart medical cooperation ecosystem participated by hospitals, operators, equipment manufacturers and application providers. The 3D image reconstruction and other services deployed on the MEC edge cloud were praised by department directors and doctors in the People's Hospital of Xinchang after they started using the services in the hospital. Zhejiang province began to build county-level medical communities in 2019 to establish a medical service system that links counties, towns, and villages. The Xinchang County Medical Community is one of the important demonstration sites. China Unicom will use Xinchang Medical Community's private 5G smart medical network as an incubation base to replicate and promote its services in Zhejiang and across the country. In 2021, the private 5G medical community network will cover 11 primary medical institutions under the Xinchang People's Hospital Medical Community, so that medical institutions can use safe and efficient private networks for mutual assistance and information sharing of medical resources. In terms of services, 3D reconstruction and other smart medical applications are gradually promoted to more clinical applications such as orthopedics, general surgery, and neurosurgery to help primary medical institutions improve their services.

China Media Group 5G + 4K/8K Production and Broadcast Platform

In accordance with the guidance from President Xi Jinping, the China Media Group ("CMG") has enhanced its innovation-driven development strategy to accelerate the development of the "5G + 4K/8K UHD Video Production and Broadcast Demonstration Platform". Capitalizing on this project, CMG seeks to realize strategic transformation to "5G + 4K/8K + AI" from the conventional technical layout, to lead 5G application in the media industry and development of UHD video industry.

Jiang Wenbo
Member of CMG Editorial Board

SOLUTION PARTNERS CMG 中央广播电视总台 CHINA MEDIA GROUP | 中国移动 China Mobile | HUAWEI | ABP | Sumavision 数码视讯

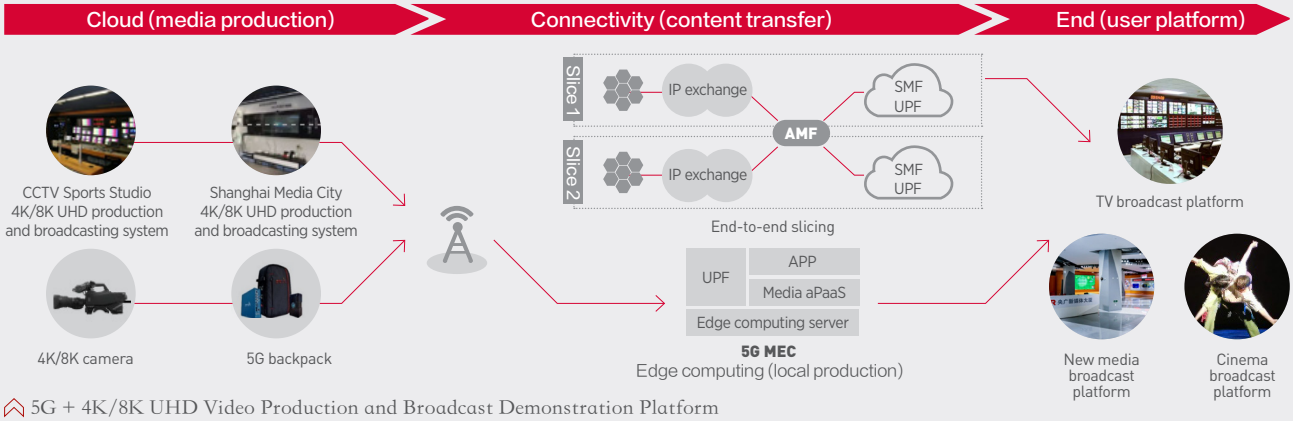
OVERVIEW

In June 2020, following the "5G + 4K/8K + AI" goal of CMG and with new technologies such as 5G and AI, a project led by the CMG relating to 4K/8K production and broadcasting systems for CMG's Beijing Headquarters and Shanghai International Media City was implemented collectively by China Mobile, Huawei, Academy of Broadcasting Planning of NRTA, Guangdong UHD Video Innovation Center and Sumavision. Additionally, a 5G network was set up in line with program production and broadcasting requirements to enhance CMG's production and distribution capacities for UHD video programs. The total investment was RMB 419 million.

Following the outdoor macrocells plus indoor distributed antenna system, the project covered private 5G networks for CMG offices in Guanghua Road, Fuxing Road and Shanghai International Media City, including outdoor areas, studios, meeting rooms, VIP rooms, office areas and key corridors. The total area exceeded 100,000 square meters. Secure connection with the CMG networks was completed to enable media asset processing in a 5G environment.

The project also had an edge computing platform for each of the above-mentioned location, including a basic system, a storage system, a 5G distribution system (UPF included) and a storage database. In addition to its large storage capacity, hardware such as GPUs was deployed for accelerated video editing and processing, facilitating the production/broadcasting of 4K/8K UHD videos.

The project will also set up a network slice operation management platform as China Mobile's portal for CMG's network slice business to support the needs of UHD video production. By end-to-end slicing in a 5G network, the stability, security and reliability of UHD video transmission are assured. The communication service management function and network slice management function required by network slicing will be established as the underlying support capacities.



5G + 4K/8K UHD Video Production and Broadcast Demonstration Platform

CHALLENGES

Industry overview

The CMG offered China's first 4K satellite channel in 2018. In the telecommunication industry, China Telecom, China Unicom and China Mobile have been offering 4K television programs via IPTV since 2015. Thanks to the growing popularity of 4K programs, China expects to see further growth of 4K TV shipment, with approximately 45 million units in 2020. In order to better democratize 4K and 8K products and drive growth of the UHD industry, on March 1, 2019, the Ministry of Industry and Information Technology, National Radio and Television Administration of the People's Republic of China (NRTA) and the CMG jointly released the UHD Video Industry Development Action Plan, which specifies the 2022 development goals of the sector, including overall coverage for 4K TVs and 5% ownership for 8K TVs.

Coordinated development of 5G and UHD

As UHD streaming requires a resolution as high as 4K and even 8K, a frame rate higher than 50 FPS, image sampling bits up to 10, and a high-dynamic range (HDR), its typical demand on bandwidth stands between dozens of megabits to hundreds of megabits. As this requirement is aligned with the 5G enhanced Mobile Broadband (eMBB), which is a relatively mature line of business, there is a solid foundation to commercialize 5G eMBB mainly targeting UHD broadcasting, making UHD video an important factor for the development of 5G.

SOLUTION AND VALUE

The 5G + 4K/8K UHD Production and Broadcast Demonstration Platform is based on a 5G network, capitalizing on its strengths in high bandwidth, low latency and broad connectivity, to facilitate the collection, transmission, production and broadcast of UHD videos for comprehensive business upgrade and higher work efficiency.

01 5G network

The 5G network for CMG headquarters includes its offices in Guanghua Road and Fuxing Road. Based on business features, in-scope areas have been classified either as a key area or a non-key area, which has been deployed with a new indoor distributed antenna system or a conventional distributed antenna system, respectively. In the case of Shanghai International Media City, 5G network coverage includes technical areas such as outdoor area and indoor studios. New 5G NR macrocells will be set up to enable full outdoor coverage, and new indoor distribution will be utilized for full indoor coverage. In this way, 5G network can be connected with the core network, edge computing nodes, air interfaces and the CMG base network to meet diversified access needs in various mobile scenarios and applications for the CMG campus, CMG Shanghai headquarters and areas outside of the campus.

02 Edge computing platform

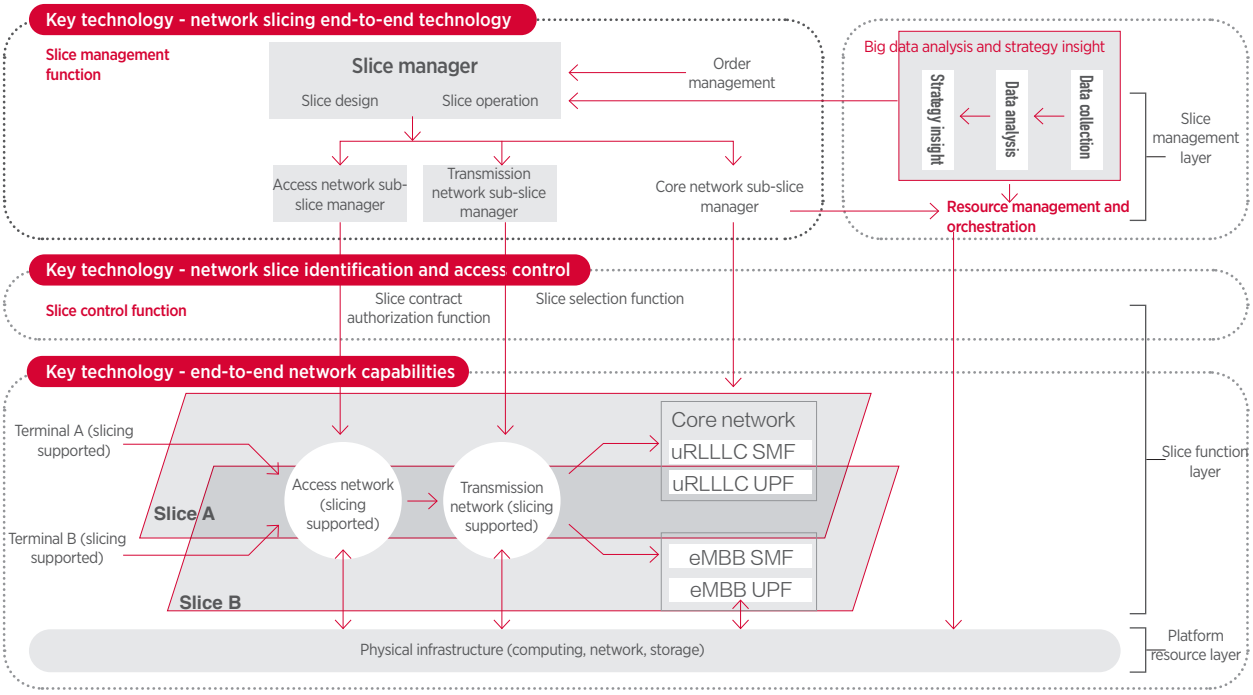
5G-based edge computing contributes to edge cloud capacities by bringing the cloud-based computing and storage capacities closer to local terminals near the users. Capitalizing on the high bandwidth of 5G network, UHD videos can be easily transmitted to the edge cloud from the user side for real-time editing, storage and transmission, significantly reducing end-to-end business latency. Comparing to the model of cloud-based production in 4G network, this approach provides greater efficiency, along with significantly higher level of reliability and security.

The uplink and downlink bandwidth of the edge computing platform can reach 1 Gbps, enabling 5G connection services in and outside the CMG campus. 10 channels of 4K-level bitrate processing capacity are needed to connect to CMG's private cloud with secure access strategies enabled. The platform offers four features, including 5G network access, UPF selection, application deployment and Internet access. The non-linear editing terminals such as mobile phone, PAD, OA machine and mobile editing terminals can access the CMG's edge computing platform via the 5G network in and outside of CMG campus for work-related purposes.

03 Network slice operation management platform

In view of CMG's 4K/8K livestreaming scenarios, as well as data security and isolation requirements in transmission, the operator's 5G SA public network slicing deployment plan has been adopted, where end-to-end network slicing resources were allocated from physically or logically isolated 5G slices in public network for media data and business. In this way, a public network is used for specific purposes to meet security and isolation requirements of the media industry.

Where congestion on network nodes such as wireless connection network, transmission network and core network occurred, the broadcasting is clear, smooth, and free from interruption. The high speed, high bandwidth, low latency and high security of 5G network enable a special channel for live-streaming.



Network slicing architecture

With the private 5G network, edge computing platform and network slice operation management platform, CMG is able to collect, edit, and broadcast UHD videos. Previously, 4G was used, and programs were produced and broadcast in SD or HD. After the private 5G network was established, CMG is able to transmit 4K videos (40 Mbps) while securing an active and stand-by transmission setting. With the transmission bandwidth reaching 80 Mbps, CMG can transmit single-channel 8K videos (160 Mbps) without freezes or blurs. The uplink bandwidth is used in real-time program transmission, as the high bandwidth feature of the 5G network and time slot allocation technology are utilized to improve uplink bandwidth for stable UHD signal transmission. With the 5G network, CMG's 5G + 4K/8K portable transmission system can easily encode and encrypt 4K/8K UHD signals generated by cameras on-the-move. UHD signals are then sent back via the 5G network. In this way, program production is empowered with much greater flexibility as UHD program production does not necessarily use fixated cameras.

IMPACT

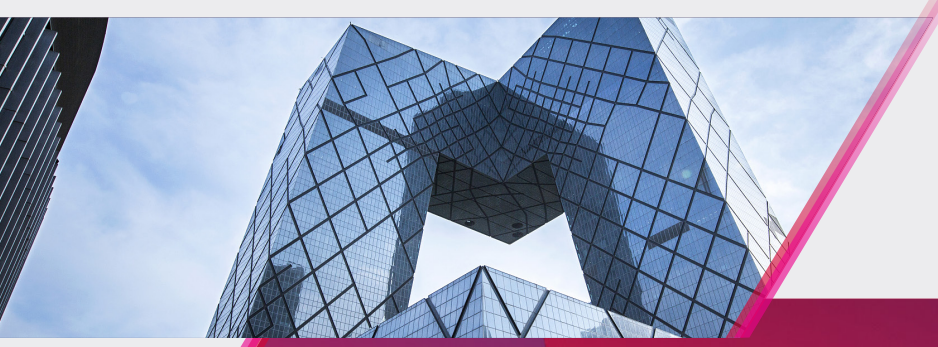
Changes to production and broadcast models: The media industry has inherent needs for wireless communication. TV program (news in particular) always involves video-taping, collection and transmission. 5G network can effectively break the geographical limitations in the process of collection, editing, production, broadcasting, distribution and viewing, enabling changes to the fixed-time/fixed-location pre-production model to a way of work free from geographical/time limitations.

Broadcast mode of new programs: High bandwidth and low latency of 5G also facilitate transmission and distribution of UHD videos and other businesses that require high bandwidth. 5G-based live news, mobile production, VR push, and multi-screen interaction have potential to become mainstream. The going-mobile trend enabled by 5G will open a new chapter for the development of media production and distribution. Scaled development of UHD program collection, production, distribution and supply will secure an offering of diversified UHD programs for audience and new media users in and outside of China on a continued basis.

REFLECTION

By the end of 2020, the private 5G network for CMG offices in Guanghua Road and Fuxing Road has been established to support basic business and operation needs.

In the upcoming phases, the edge computing platform will be set up in Guanghua Road office to enable at least 10-channel 4K-level bitrate processing capacity. In addition, the platform will host editing applications to facilitate livestream recording, media processing, integrated production, and production on mobile phones to meet CMG's diversified needs in video editing. We will also work with CMG in testing the network slicing for 4K UHD broadcasting to secure stable program broadcasting without interruption to signal transmission amid traffic congestion on the core network. Furthermore, business requirements on network slicing will be specified and the network slicing operation management platform will be customized based on business requirements of CMG and other media entities to provide network slicing wherever and whenever needed and ensure real-time transimission for news materials.



5G New Media Platform of China Media Group

The scaled 5G deployment and commercialization in China will further drive new applications of 5G technologies. In terms of the media sector, the highlight of commercialized 5G application is Ultra HD ("UHD") streaming. It has been noted that increasing application scenarios and market demands on UHD streaming have been stimulated by 5G, fueling substantive development of the media sector and incubating new business models. In the coming future, China Unicom will continue to deepen 5G applications in the media sector, and engage with relevant stakeholders in industrialized application of 5G in new media and convergence media, so as to contribute to economic restructuring and innovation-driven development in China.

Ren Ligang
CTO of China Unicom (Beijing) Industrial Internet Operation Center

SOLUTION PARTNERS

CMG 中央广播电视总台 CHINA MEDIA GROUP | China unicom中国联通 | HUAWEI

OVERVIEW

In 2018, China Unicom and Huawei jointly completed a project on multiple 4K/8K UHD signal transmission via 5G exclusive network in CMG's Guanghua Road offices with satisfactory live-streaming performance. In 2019, CMG partnered with China Unicom and Huawei (collectively the "three parties") to trial on the 5G+4K/5G+8K/5G+VR live-streaming, where satisfactory performance of CMG's 5G new media platform has been recorded in streaming campaigns for major events, including the military parade of the 70th Anniversary of the Founding of PRC, the 7th CISM Military World Games in Wuhan, Belt and Road Forum, MWC Shanghai, National Broadcasting Media Conference as well as sports events.

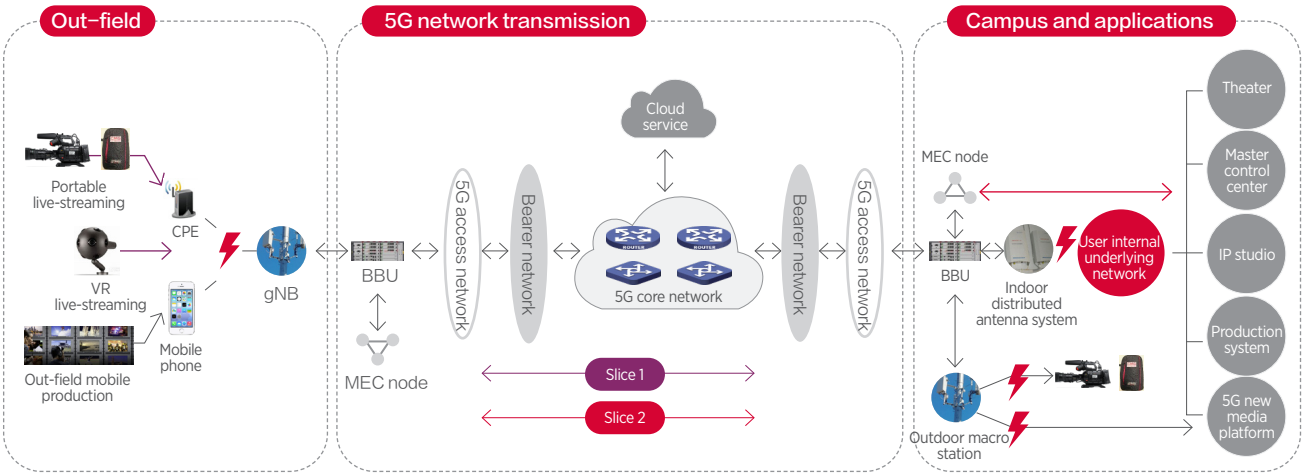
In May 2020, in order to provide assurance on stable operations of 5G in UHD video transmission, the three parties collaborated on testing 5G live-streaming end-to-end slicing and MEC-based non-linear editing. Capitalizing on flexible slicing deployment and bandwidth scheduling, the 5G wireless network and the core network provided higher-level SLA assurance. When professional streaming equipment of the CMG 5G new media platform was used, live-streaming quality was free from impairment, without any screen freezing or blurs. This project has validated that 5G slicing has the capacity to secure stable transmission in UHD streaming. In the 2020 China International Fair for Trade in Services ("CIFTIS") held in Beijing in September, the slicing outcome was utilized to secure mutli-link 8K UHD live-streaming for CMG. China Unicom also worked with Huawei on non-linear editing testing based on operator's MEC for CMG, which was a beneficial attempt to facilitate further use of 5G technologies in key production process of the media industry and further drive 5G applications in TV news live-streaming.

CHALLENGES

When live-streaming from out-field, the cable transmission and microwave transmission approaches are currently in use in the front-end acquisition systems to return UHD signals. In this case, broadcast vans need to be deployed on-site for directing and editing purposes. However, high costs and complex upgrading are associated with the use of broadcast vans. Moreover, cable transmission involves complicated wiring/de-wiring procedures and low mobility, while micro-wave transmission has special requirements for weather and locations. This mechanism has created significant constrains on TV program production, making it difficult to keep up with the new requirements of a fast-growing new media sector. It has come to a understanding where an industry-wide revolution is needed on the media front-end production. Given the high uplink bandwidth and low latency enabled by 5G technology, a revolution in streaming, including collection, content-making, and high-speed distribution, will be inspired. The 5G slicing technology can provide reliable support on end-to-end uplink bandwidth to resolve the bandwidth issue in 4K/8K UHD transmission. Additionally, slicing can be utilized on a pay-as-you-go basis just like cloud services. 5G-based MEC video editing and transcoding and distribution have made local editing possible, which has opened a new chapter where 5G injects new vitality to the development of media industry.

SOLUTION AND VALUE

Thanks to these collective efforts, the CMG 5G new media platform has made multiple achievements and significantly driven the revolution of new media production.



01 Portable 5G UHD Transmitter (a.k.a. "5G Backpack")

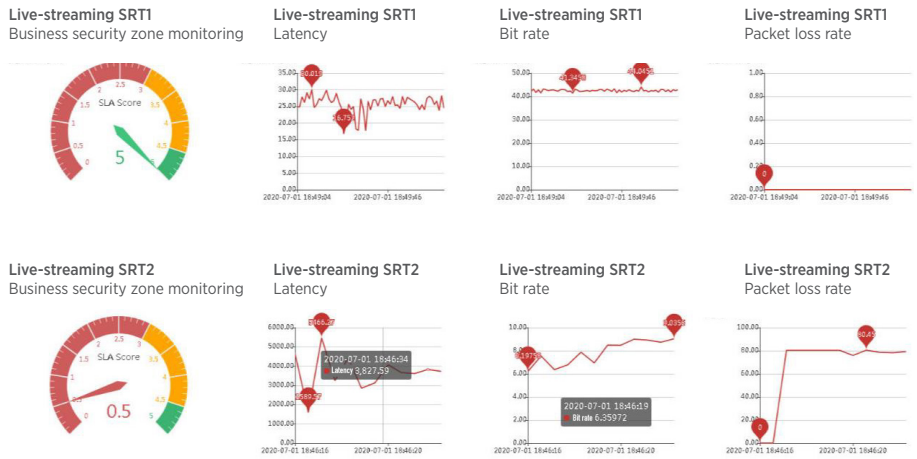
The portable 5G UHD transmitter, consisting of a 5G communication module, an HEVC encoder, and a power pack, is suitable for portable interviews conducted on individual level at remote locations. The 4K source videos collected by the front-end camera are transmitted to the 5G backpack. After being encoded by the built-in 4K HEVC encoder, the videos are uploaded via the operator's 5G network using the CBT multi-link aggregated transmission technology. In the back-end, signals are received via the VPDN leased line and then decoded, previewed, and transferred by the server reception management software. Eventually, the final products are broadcasted by the live-streaming platform. Compared with H.264, HEVC encoding saves up to 50% bandwidth on the same level of frame quality in terms of bit rate. Effective compression technology can realize greater transmission efficiency using the same bandwidth in the transmission process. The 5G backpack also supports a low-latency model, which was applied successfully in CMG's live-streaming (5G+4K) for the 70th anniversary military parade campaign. In the meantime, China Unicom and CMG jointly released the CMG 5G Media Application White Paper, which has proposed a new business model of media industry in 5G network, and provided business/technical standards for key parts including collection, transmission, mobile cloud-based production, VR making, and distribution. The report has laid a solid foundation for the in-depth integration of 5G in the media sector for fast growth.

02 Application of 5G Slicing in Media Live-streaming

In collaboration with CMG, Huawei, and other partners, China Unicom conducted an analysis of live-streaming scenarios and prepared slicing templates based on different SLAs accordingly. Through end-to-end slicing tests in 5G wireless network, bearer network, and core network, we have validated the effect of slicing on live-streaming latency, bit rate, and frame loss rate in 5G-related scenarios. Satisfactory results have been recorded in this regard. These tests were executed in compliance with relevant standards in the latest version of China Unicom NR Wireless Side QoS Standardization Parameter Set_v7 and China Unicom Slicing Classified Templates Transmission Business Standards. See details below:

Business	5QI	Uplink scheduling factor	DSCP	FlexE slice	Queue	DNN
General live-streaming	9	200	26	None	AF3(WFQ)	bjzq.5Gqptest1.bjapn
Internet celebrity live-streaming	8	400	18		AF2(WFQ)	bjzq.5Gqptest1.bjapn
High-value live-streaming	6	800	18		AF2(WFQ)	bjzq.5Gqptest1.bjapn
Special guarantee live-streaming	4	GBR	34		EF(PQ)	bjzq.5Gqptest2.bjapn

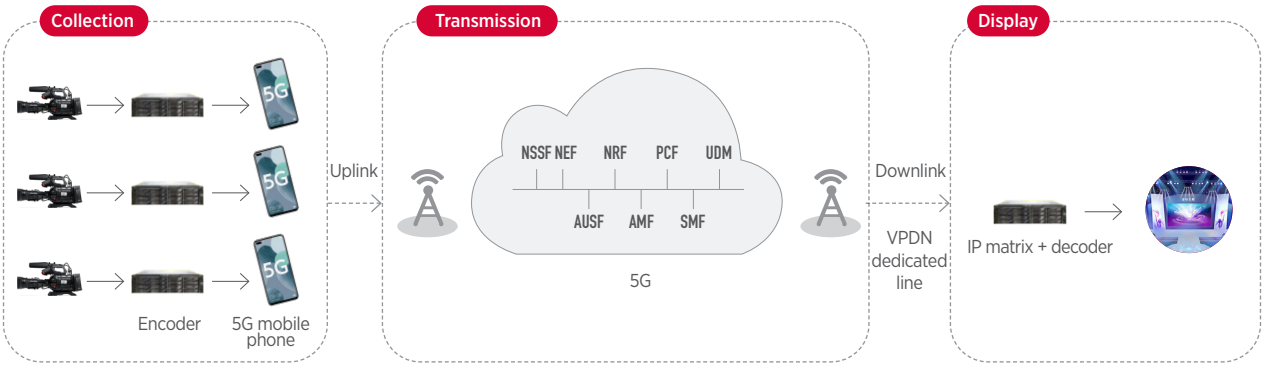
According to the tests, the non-GBR (where 5QI=6/8/9) allocated air interface resources in line with the 5QI scheduler rates amid competition (when all other conditions were the same). When GBR and non-GBR competed over air interface resources, GBR was prioritized for resource allocation before non-GBR. 5QI soft slicing is one of the most cost-effective plans for fast deployment that is available in the market.



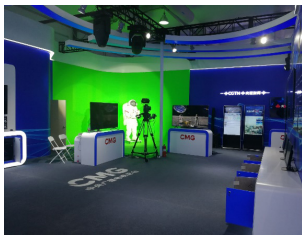
Changhua Building simulation software testing results by China Unicom Beijing

New media platform testing results on Floor 49 of New CMG Building

In the meantime, using the professional streaming equipment of the CMG 5G new media platform, we created uplink congestion of 5G indoor distribution via single-line 4K UHD video and single-line 8K UHD video. From the actual images from the test, the 4K UHD video (where 5QI=4) was nearly free from any implication, while the 8K UHD video (where 5QI=8) experienced serious blurry screen and freezes. The test has evidenced that value-added slicing EF queue or exclusive slice network has better quality and can provide greater support for live-streaming scenarios that need special assurance (a.k.a. special-purpose live-streaming). Relevant stakeholders also conducted FlexE and RB slicing test on the bearing side to better prepare for RB slicing products for RB resource reservation on a forward-looking basis.



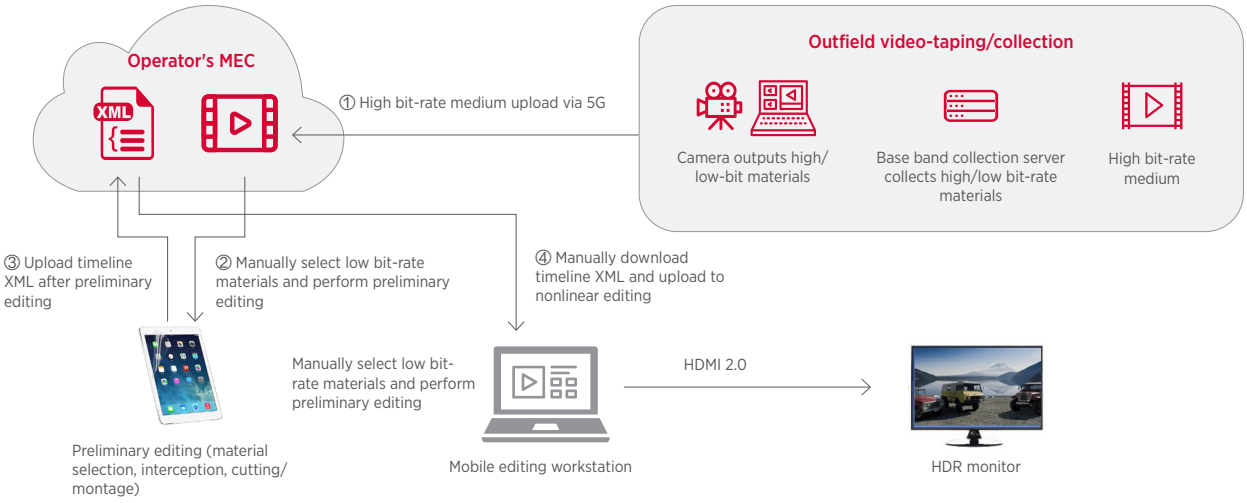
During the 2020 CIFTIS, China Unicom took the lead in implementing the real-world application of the above-mentioned test results relating to 5G slicing and VPDN technology. Using the 5QI slicing technology, we realized concurrent transmission of 8K UHD video signals in three channels at CMG premises with secure stable bandwidth at 160 Mbps for each channel. The 5G private network was utilized to transmit uplink traffic at 500 Mbps for big screen display. It was the first successful real-world application of 5G slicing and 5G exclusive network by China Unicom.



03 Application Based on Operator's 5G MEC

In August 2020, China Unicom partnered with Huawei and other companies in implementing the application based on China Unicom's district MEC in Xisanqi, including provision of computing and storage resource pools such as virtual machine, GPU, and NAS. CMG deployed its non-linear editing software in these resource pools to trial on MEC-based editing and production in 5G network. The non-linear editing software was operated and rendered on the cloud, where the editing UI was displayed at local thin client through the remote projection technology, and the MEC-end fluidized the HDR monitoring frame and pushed it to the local thin client in real time. By outputting the HDR frame for monitoring purpose via graphics card HDMI, the issue that high-quality monitoring was not accessible in cloud-based production was addressed. This model has the potential to significantly drive non-linear editing efficiency.

In accordance with previous testing results, the 5G + MEC model can meet the requirements of 4K UHD online editing in terms of uplink/downlink rate and latency. Overall, the application of virtualized nonlinear editing deployment based on the operator's edge cloud is feasible, which serves as a good start for further testing and research work.



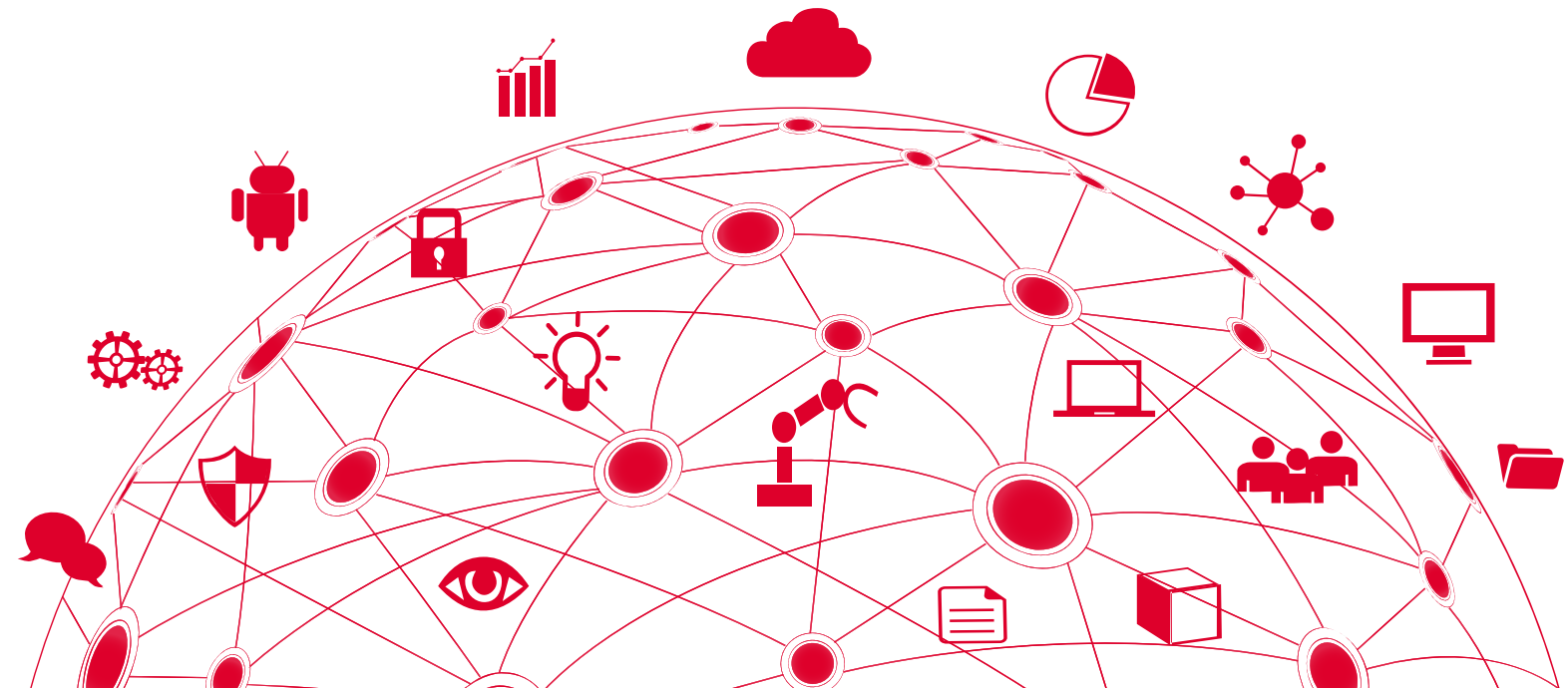
REFLECTION

As the 4K UHD video transmission requires a bandwidth between 40 and 60 Mbps (in the case of 8K UHD video transmission, a bandwidth between 100 and 160 Mbps), 5G network can well secure an uplink bandwidth above 100 Mbps. In addition, the 5G slicing technology can address the packet loss, jittering, and latency issues in video transmission. Through the on-site tests and applications implemented for CMG, we have validated that the uplink bandwidth and reliability of 5G network can serve the purpose of 4K/8K UHD video live-streaming campaigns. Through the slicing tests, we have formulated slicing templates and slicing product design methodology to support upcoming customizable product offering, where media live-streaming slicing products can be procured via CSMF and NSMF (automated operation platforms for slicing products).

Capitalizing on the MEC-based 5G+4K UHD collection and editing system, CMG is able to store videos collected from remote locations on the MEC, and significantly improve production/broadcast efficiency via non-linear editing based on operator's MEC. On top of that, local flow will be enabled via MEC to reduce the impact of video traffic on 5G core network and achieve lower latency.

Along with the improvement and optimization of 5G technologies, 5G slicing and MEC will continue to fuel new growth in UHD live-streaming, incubate new business models, and drive changes in the way of production in the new media sector.

5G



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