China 5G Vertical Industry Progress and Research Requirements Quarterly Report

May, 2020

1. Contributor List

- Editor

  CCSA (China Communications Standards Association) http://www.ccsa.org.cn/

- Others

  - ✓ 5GDNA (5G Deterministic Networking Alliance) https://www.5gdna.org/
  - ✓ 5GSA (5G Slicing Association) http://5gnsa.org/
  - ✓ 5GAIA (5G Applications Industry Alliance) http://www.5gaia.org/

2. Key Messages & Suggestions

- ✧ China 5G Vertical Industry in this quarter report includes Multimedia, Smart Factory, Mobile Health, and Smart Grid.
- ✧ POC of the initial phases have been finished for all these 5G vertical industries in China. The value and value chain are clear, and the use cases are being put into commercial use right now.
- ✧ While, the new vertical terminals, further convergence of 5G and vertical industries, and E2E enhancement, would be the key for next step scale commercialization.
- ✧ Suggestions
  - ✓ European partners could learn the experiences from China 5G vertical industry top use cases, and start commercial use with less difficulty.
  - ✓ China and Europe corresponding partners could closely cooperate on the further requirements from the 5G vertical industry top use cases, not only on the technology research and standard enhancement, but also the industry bottlenecks.

3. Detailed Information

3.1 5G Multimedia

A) General Plan

	2020	2021	2022	2023	2024	2025
HD Video	Carrier Class 4K		Ultimate 4K		8K	
VR/AR	Weak -Interactive Cloud Games		Strong-Interactive Cloud Games		Partially Immersive Strong-Interactive Services	Fully Immersive Strong-Interaction services

Table 1 - 5G Multimedia General Plan

B) Top Use Cases – Smart Stadium

China Sports Media, telecom carriers, and telecom vendors are working together to build a 5G smart stadium in Olympic Sports Center in Jinan, Shandong Province.

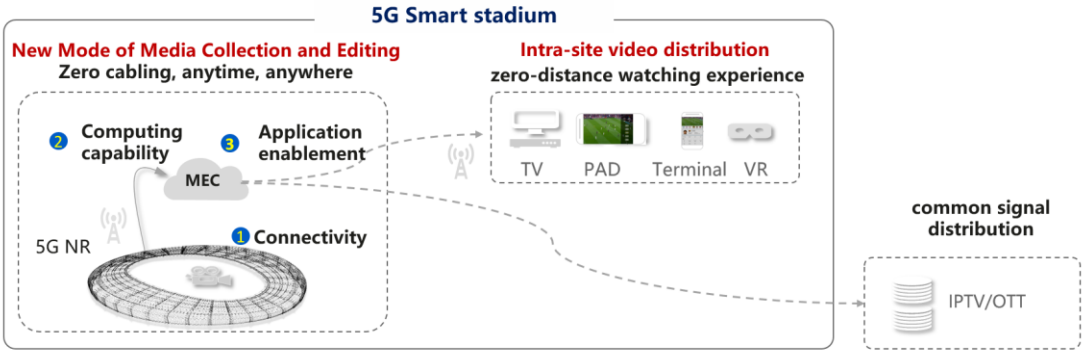
Picture 1 - 5G Smart Stadium Overview

The project is divided into two stages. The 1st stage is "editing & communication", mainly used for sports competitions and commercial show for China Sports Media. The 2nd stage is to cooperate with stadium operators to digitize stadiums and enable "Internet + sports" and "Internet + stadiums".

Now it is in the first phase, solution development and lab tests have been completed based on the 5G SA network.

Lab test - The broadcast-level production system consists of one group of 4K video servers, six groups of HD codecs, one group of 4K codecs, and video switching and monitoring devices. Adjust the video encoding bit rate to 10 Mbit/s, 15 Mbit/s, 25 Mbit/s, 30 Mbit/s, 50 Mbit/s, and 80 Mbit/s step by step. After the video is decoded, the video of the monitor is fluent without mosaics, the image details can be completely restored, the average RTT delay is within 10ms, and the packet loss rate is close to 0%. In the lab environment, multimedia services are provided, such as 4K ultra-HD and multi-channel high-definition (HD) stand-alone signals, and the 5G core network supports an end-to-end delay of 10 ms in addition to the fixed encoding and decoding delay. The relative delay of multi-position synchronization is within one frame, which can meet the requirements of remote production and even the requirements of remote reverse control and monitoring.

The outdoor solution has been deployed, and would be available soon in the first half of this year.



Picture 2 - 5G Smart Stadium Solution

Application of 5G capabilities

- ✓ Uplink capability based on slices - The uplink data rate of 17* 4K cameras reaches 1 Gbit/s.
- ✓ MEC based editing - Non-linear editing, VR stitching, multi-view production, short video production, AR game watching, and AR navigation.
- ✓ MEC based targeted streaming - Considering copyrights, the super venue service is open only to paid users. The maximum downlink data rate is 100 Gbit/s.
- ✓ Other capabilities - Positioning, frame synchronization technology, and UHD encoding and decoding.

C) Research Requirements

(1) Build a 5G+UHD/VR video production and communication platform based on MEC to enrich video content. (2) Supports source aggregation, signal scheduling, transcoding, content playback control, and playback distribution of ultra-large UHD/VR streams with 5G systems. (3) Supports UHD/VR video encoding formats such as H.265/HEVC and AVS2.0, HDR technologies, and immersive audio. (4) Implements 5G network transmission of UHD/VR video streams, optimizes Internet protocols such as SRT, and supports revision of related industry standards. (5) Large-scale application of 5G+UHD/VR videos. The smart stadium is a transformation of media production from traditional SDI/HDMI wired transmission to IP-based 5G wireless transmission. Currently, mainstream professional cameras cannot directly output IP streams or use 5G for transmission. They need to connect to 5G backpacks (encoders and 5G transmission modules). There is still much room for improvement in terms of integration and convenience.

3.2 5G Smart Factory

A) General Plan

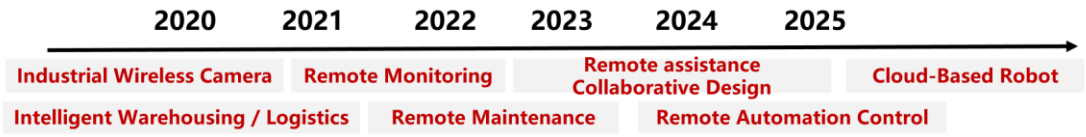
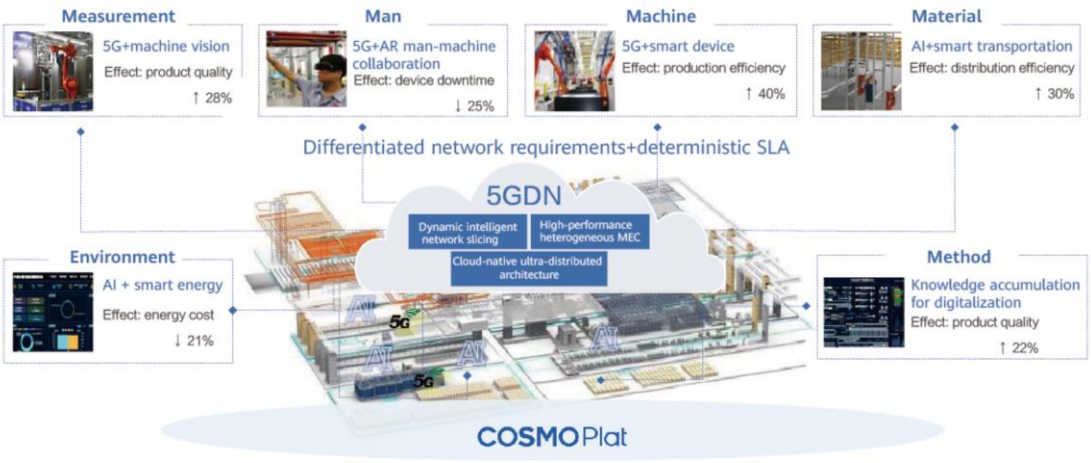


Table 2 - 5G Smart Factory General Plan

B) Top Use Cases – Haier Smart Factory

In July 2019, Haier, together with telecom carriers and telecom vendors, officially released the world's first 5G smart factory at the “Industrial Internet Ecosystem Innovation Forum” of the World Industrial Internet Industry Conference in Qingdao. The solution include 5G deterministic network, the cloud native ultra-distributed architecture, dynamic intelligent network slicing, and the key technologies of super-performance heterogeneous MEC. The solution could provide “differentiated + deterministic” network service capabilities, build intelligent, complex and multi-scenarios manufacturing systems, such as 5GDN + intelligent devices, 5GDN + machine vision, and 5GDN + AR man-machine collaboration. And the solution could implement full-process information self-sensing, full-element event self-decision, and full-cycle scenario self-iteration.



Picture 3 – Haier 5G Smart Factory

Based on the intelligent upgrade of 5G deterministic networks, the Haier industrial park explores more scenario-based IoT smart products, smart portfolio solutions, and 5G+AI technology applications through data-based simulation modeling verification, efficient production collaboration, and precise quality control.

Algorithms are migrated to the cloud, and data is secured within the factory. This effectively improves the efficiency, security, and labor costs of traditional factories, meeting the requirements of smart operations. The product quality is improved by 28%, the number of device downtime faults is reduced by 25%, the production efficiency is improved by 40%, and the investment cost is reduced by 30%.

In addition, the factory implementation details need to be considered for the 5G commercial scenarios. For example, in machine vision, the range of industrial camera pixels and uplink bandwidth varies greatly based on the factory's requirements on identification, detection, measurement, and positioning. For low-precision defect detection

and bar code identification (such as two-dimensional code, one-dimensional code, and OCR characters), a camera with 30–200 megapixels can be used. However, for high-precision positioning, measurement, and detection, for example, sub-millimeter-level positioning and detection of very small particles are required, the 1500+ megapixels cameras need to be enabled, which has higher requirements on the 5G uplink bandwidth. Therefore, during commercial deployment in factories, you need to determine whether to use lossy or lossless compression and the deployment solution based on network performance, visual application scenarios, and production cycle.

C) Research Requirements

(1) In an enterprise or campus, deploy the virtual enterprise private network with 5G base stations and the MEC platform. (2) Deploy 5G terminal modules in industrial terminals or equipment. (3) Make full use of existing platform resources or build a collaborative manufacturing operating system cloud platform to interwork with mainstream industrial platforms. Implement the usages, monitoring, and management of a large number of terminals based on 5G network. (4) Implements industrial applications in specific scenarios and supports the revision of industry standards such as 5G + AGV and 5G + machine vision.

3.3 5G Mobile Health

A) General Plan

Table 3 – 5G Mobile Health General Plan

B) Top Use Cases - Medical Alliance in Futian District, Shenzhen

In 2019, medical application companies worked with telecom carriers, telecom vendors, and device partners to help hospitals provide 5G telemedicine services for patients, including remote audio & video consultation and remote image diagnosis. Through the 5G deterministic network, experts and doctors in the central hospital help the doctors in the clinics provide better medical services for patients. The following table lists the capabilities of the 5G deterministic network for telemedicine.

5G Network （with MEC）Capabilities	Medical Application Scenarios	Network Requirements
Connectivity	4K Video	Data rate uplink >20Mbps E2E latency 50~100ms

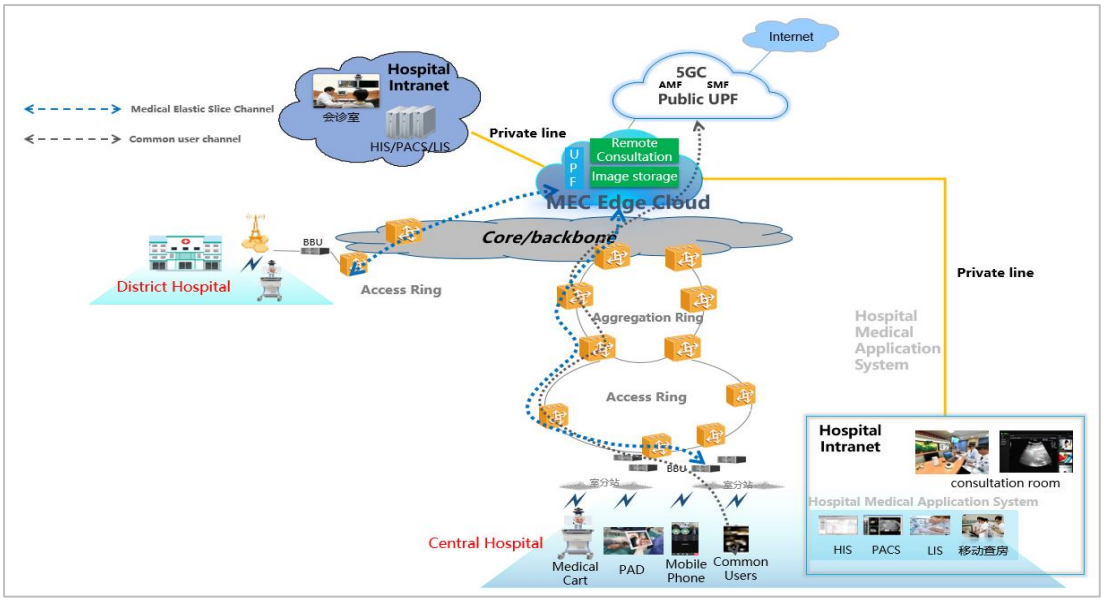
	PACS Image Data	Data rate >5Mbps E2E latency 50~100ms
Computation	AI-assisted diagnosis	AI Computing capability
	3D image reconstruction	E2E latency <1s
Security/Isolation	Remote consultation	Data in hospital

Table 4 – 5G deterministic network Capabilities for telemedicine

Telecom carriers deployed 5G private networks for the medical alliance in Futian District, Shenzhen, and deploy third-party PACS systems, AI-assisted diagnosis, and video systems based on the MEC platform. MEC and Slicing are as follows,

	Domain	Project Name	Construction Content
1	MEC	5G MEC Gateway	The MEC private network gateway (dedicated UPF) provides medical service identification and local traffic breakout for hospitals, community health centers, ambulances, and medical examination vehicles. In this way, services are locally closed, and data is kept inside the hospitals, meeting the requirements for medical service security and latency.
2		MEC Edge Cloud	Telemedicine applications are deployed on the edge cloud to meet the requirements of high-performance agile and elastic computing. It supports fast and flexible deployment of innovative services of the medical alliance, and reduce service latency by moving computing to the edge. It also ensures data security and implement cross-hospital interconnection and data sharing, in addition, firewalls are deployed to ensure network security in one hospital. Converged deployment with the 5G MEC gateway and connected to the local equipment room of the hospital/community health center through private lines.
3	Slicing	5G Slicing Services	The 5G network slicing provides E2E slicing capabilities covering the wireless, transport, and core networks. It separates medical services from public services at the network layer to ensure service SLA.

Table 5 – 5G deterministic network MEC and Slicing for telemedicine



Picture 4 – 5G Private Medical Network

5G private medical network has 3 values. (1) Streamline the pre-operation, in-operation, and post-operation processes to improve doctors' efficiency by 20%. (2) Video and medical image data is directly transmitted and processed among hospitals. The latency is reduced without frame freezing. The response time of 3D image reconstruction is reduced from 3 seconds to 1 second. (3) All data is stored in the hospital MEC to guarantee the security.

C) Research Requirements

(1) Currently, medical terminals access the 5G network by connecting to external 5G CPEs. The specifications and plan of medical terminals with built-in 5G modules need to be studied. (2) The new standard is being drafted for the convergence of the communications industry and the medical industry, helping the 5G deterministic network enable the transformation of the medical industry to mobile, remote, and intelligent.

3.4 5G Smart Grid

A) General Plan

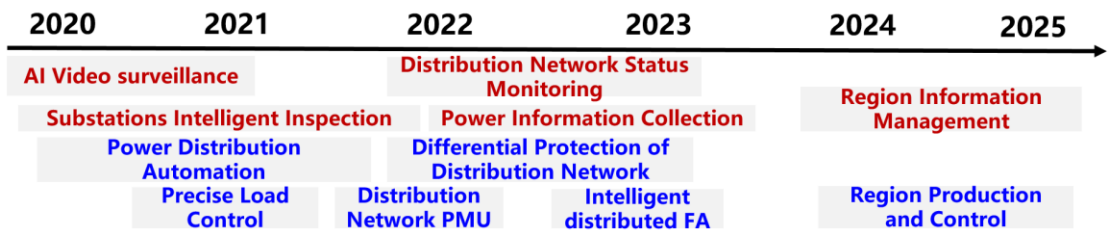


Table 6 – 5G Smart Grid General Plan

B) Top Use Cases - China Southern Power Grid

The power grid system mainly comprises five parts: generation, transmission, transformation, distribution, and consumption throughout delivery of electric power. The backbone power communication network is responsible for power generation, transmission, and transformation which has been fully covered with the optical private network in China. The terminal access network is responsible for power distribution and consumption with features of wide-area coverage and ubiquitous access. The deployment of traditional optical private networks for the terminal access network is costly and time-consuming, and is unsuitable for special terrains such as bridges and elevated roads. Thus cannot cater for wide-area ubiquitous access and there are still some considerable coverage blind spots that affect services. In addition, mobility scenarios, such as substation robot inspection and UAV-assisted inspection of power lines, place high demands on wireless networks. To address all these issues, a ubiquitous, flexible, economical, and reliable wireless network is urgently required.

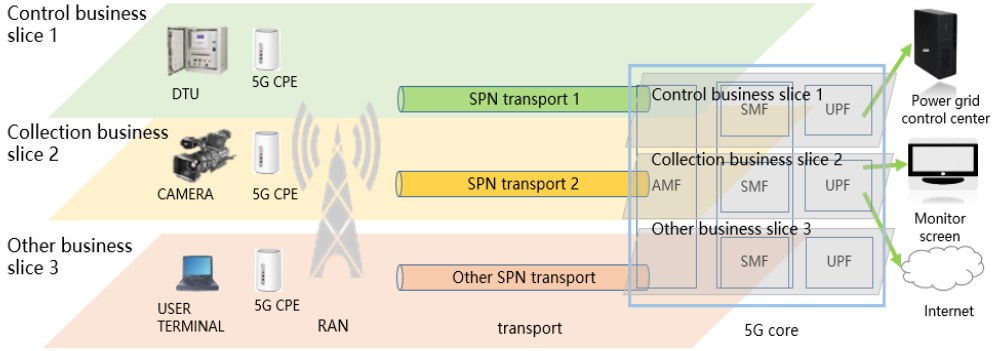
Based on the network slicing technology, 5GDN can virtualize a wireless private network to implement higher security isolation and customized resource allocation. Based on the technologies such as 5G MEC and 5G TSN, 5GDN can realize lower latency and more deterministic connections. Thus 5GDN can effectively supplements the existing electric power communication private network to solve bottleneck and challenges facing wireless communication services such as intelligent power distribution and inspection.

Let's take the differential protection for power distribution as an example. 5GDN's differentiated network capabilities can achieve ultra-low latency, ultra-high precision synchronous timing, and high reliability. The dedicated network for the 5GDN can meet the strict security isolation requirements of the virtual private network of the electric power industry. In addition to this, the self-service network capability can be exposed through northbound APIs to allow electric power customers to autonomously perform O&M and management within the specified scope, such as the network slicing KPI visualization and intra-slice user management. Therefore, the 5GDN based differential protection solution for power distribution can provide more efficient and flexible access solutions with high security and isolation in the electric power industry. Compared with traditional optical fibers, it can effectively reduce deployment costs and greatly improve service provisioning efficiency.

Since 2018, China Southern Power Grid, telecom carriers, and telecom vendors have started strategic cooperation on 5G + smart grids. The joint team have comprehensively promoted 5G + smart grid application research in terms of top-level design, international standards, key technologies, live network pilot, terminal modules, and service operation, and have made significant breakthroughs in both technical and business aspects, and achieved multiple No. 1s in the world.

In June 2019, China Southern Power Grid Shenzhen Power Supply Bureau, telecom carriers and telecom vendors completed the industry's first commercial-oriented 5G power slice field test in Shenzhen. In this project, they completed the industry's first 5G

differential protection test for power distribution, as well as a slice isolation test for the 5G CN and TN network. Besides that, the industry's first 5G B2B network slicing management platform also be built.



Picture 5 – 5G Smart Grid Slicing Solution

C) Research Requirements

5G technology research is carried out throughout the entire process of generation, transmission, transformation, distribution, and consumption. It involves not only internal power grids, but also external organizations such as telecom carriers, equipment vendors, and standards organizations. It also involves the establishment of the standard system, management models, and business models. It is a complex and systematic project.

(1) Technical standards and industry support - 5G vertical standards have not been completed, and telecom carriers do not have the complete 5G vertical service networks. The verification of typical services covering the entire power grid has not been completed, and the large-scale commercial use of customized 5G communication terminals needs time. The market scale and industry chain need to be further expanded. (2) Adaptation between technologies and services - There is no systematic architecture design that deeply integrates smart grids and 5G networks for large-scale applications. Some key 5G technologies that support power grid service applications need to be researched. The security isolation of 5G network slices to carry power grid services in different areas needs to be verified, the intelligent control and reliability assurance capabilities of power grid services and 5G slicing resources need to be improved. The 5G business model between telecom carriers and grids still need to be improved. The E2E SA network slicing process is not matured for the actual service operation. (3) Terminal heterogeneity and telecom carrier system differences - Due to terminal heterogeneity and telecom carrier system differences, 5G power applications must be verified by multiple telecom carriers before being scale commercialization.

Zemin Yang
CCSA
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